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The purpose of this publication is to assist engineers in the analysis, design and control of paving projects that use asphalt concrete and other asphalt plant-mixes. The scope of this new third edition has been enlarged, and changes necessitated by advances in asphalt technology have been incorporated. Chapters I and II and Appendices A and B present information that is designed to help the engineer analyze an asphalt paving project and prepare the project's engineering report. Chapter III is intended as a guide to the preparation of materials and construction specifications in accordance with decisions based on the recommendations of the engineering report. Tables and graphs are used to support specifications and construction methods. (RK)

Specifications and Construction Methods for Asphalt Concrete

AND

OTHER PLANT-MIX TYPES

SPECIFICATIONS AND CONSTRUCTION METHODS FOR ASPHALT CONCRETE (SS-1)

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THE ASPHALT INSTITUTE

THIRD EDITION JUNE 1964

Specification Series No. 1 (SS-1)

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AND

OTHER PLANT-MIX TYPES

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FOREWORD

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Chapters I and II and Appendices A and B present information that is designed to help the engineer analyze an asphalt paving project and prepare the project's engineering report. Chapter III is intended as a guide to the preparation of materials and construction specifications in accordance with decisions based on the recommendations of the engineering report.

Other Asphalt Institute publications have been referred to in the text of this book. Information about them may be obtained from any of the engineering offices of the Institute listed in the back pages. The men who staff these offices will welcome the opportunity to serve you.

The Asphalt Institute
Asphalt Institute Building
College Park, Maryland
June 1964

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Chapter I

INTRODUCTION

1.01 PURPOSE AND SCOPE.—This publication is concerned with three major items: (1) an introduction, including a method of classification of asphalt paving mixes and information on the use of asphalt viscosity as a means of controlling application temperatures; (2) procedures for developing specifications; and (3) construction specifications for asphalt concrete and other plant-mix asphalt paving. The appendices contain information on plant-mix pavements (including the "cold-laid mixtures") using liquid asphalts, and certain general information.

By following the procedures outlined in this manual, the engineer will be able to prepare specifications which may include special characteristics of physical dimension, quality, and financial investment according to local requirements and limitations. He should be constantly mindful that The Asphalt Institute specifications recommended herein may be modified to conform to local practice where there is sufficient service record to demonstrate satisfactory results from these practices, and where economies may result from such modification.

Information pertaining to highway location, right-of-way, sight distance, soil analysis and geometric design is not included in the text, as most highway engineering textbooks deal extensively with these subjects.

The Asphalt Plant Manual, Manual Series No. 3 (MS-3) and *Asphalt Paving Manual,* Manual Series No. 8 (MS-8), The Asphalt Institute, contain additional detail on equipment, construction methods, and inspection and control.

1.02 PLANT-MIX TYPES.—

(1) **Plant-Mix.** A mixture, produced in an asphalt

mixing plant (hence the term), which consists of mineral aggregate uniformly coated with asphalt cement or liquid asphalt. The mixture is then transported to the job site, spread by a paving machine, motor grader, or other means and compacted by rollers to produce a smooth paving course.

(2) **Cold-Laid Plant-Mix.** A plant-mix which may be spread and compacted at atmospheric temperature.

(3) **Hot-Laid Plant-Mix.** A plant-mix which must be spread and compacted while at an elevated temperature. To dry the aggregate and obtain sufficient fluidity of the asphalt (usually asphalt cement), both must be heated prior to mixing—giving origin to the term "hot-mix."

(4) **Asphalt Concrete.** A high quality, thoroughly controlled hot mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform dense mass. Typified by Asphalt Institute Type IV Mixes (refer to Table II-8).

(Additional standard usage asphalt paving terms may be found in *The Asphalt Handbook*, Manual Series No. 4 (MS-4), The Asphalt Institute.

1.03 CLASSIFICATION OF ASPHALT PAVING MIXES.—Asphalt paving mixes may be produced from a wide range of aggregate combinations, each having its own particular characteristics and suited to specific design and construction uses. Aside from the amount and grade of asphalt used, the principal characteristics of the mix are determined, in the main, by the relative amounts of:

(1) Coarse Aggregate (retained on No. 8 sieve)*
(2) Fine Aggregate (passing No. 8 sieve)
(3) Mineral Dust (passing No. 200 sieve)

The aggregate composition may vary from a coarse-

** It is recognized that various agencies use different screen sizes as the point of separation between fine and coarse aggregate. After weighing the reasons for the several break points, The Asphalt Institute has adopted the No. 8 sieve as the separation screen between fine and coarse aggregate asphalt mixes.*

textured mix having a predominance of coarse aggregate to a fine-textured mix having mostly fine aggregate.

To sort out these variables, The Asphalt Institute classifies asphalt paving mixes into eight major types, based on the relative amounts of coarse aggregate, fine aggregate and mineral dust. The general limits for each mix type (I through VIII) appear in chart form (See Figure I-1) along with the paving mix designation and the maximum size aggregate *normally* used for each of the eight mix types included.

The chart is based on the proportions of coarse and fine aggregate in the paving mix used to establish the mix type and on the proportion of mineral dust, the normal limits for which are represented by shaded bands. This type of representation is used to denote "flexible" limits as opposed to a "fixed" numerical value.

Figure I-1 denotes the range of mineral dust for each mix type. For any given combination of coarse and fine aggregate (i.e., mix type), surface course mixes will usually contain more mineral dust than base course mixes. Therefore, base course mixes will *normally* fall on the left side of the chart, as indicated, and surface course mixes to the right. Leveling course mixes may fall in either area. It should be emphasized, however, that there are exceptions.

This method was developed to classify the terms and designations for plant-mix asphalt paving used locally throughout the country. The terms and limits included agree in general with over-all practice but may be at variance with the practice of a given local area. Aside from the advantages of standardizing terms, this method of paving mix classification permits a logical subdivision of each mix type into a series of mix compositions having specific design uses, such as *surface course, plant-mix surface treatment, leveling course,* or *base course.* The description, principal usage, and paving applications for the complete series of mix compositions are outlined in detail in Chapter II.

PAVING MIX DESIGNATION		MAXIMUM SIZE AGGREGATE NORMALLY USED	
Type	DESCRIPTION	SURFACE AND LEVELING MIXES	BASE, AND LEVELING MIXES
I	MACADAM		2½"
II	OPEN GRADED	⅜" — ⅝"	⅝" — 1½"
III	COARSE GRADED	½" — ⅝"	⅝" — 1½"
IV	DENSE GRADED	⅜" — 1"	1" — 1½"
V	FINE GRADED	½" — ⅜"	⅜"
VI	STONE SHEET	⅜" — ⅝"	⅝"
VII	SAND SHEET	⅜"	
VIII	FINE SHEET	No.4	

[1] CRITICAL ZONE ← DUST CONTENTS IN THIS REGION SHOULD NOT BE USED WITHOUT A SUBSTANTIAL BACKGROUND OF EXPERIENCE WITH SUCH MIXES AND/OR SUITABLE JUSTIFICATION BY LABORATORY DESIGN TESTS.

[2] INTERMEDIATE ZONE ← DUST CONTENTS IN THIS REGION SOMETIMES USED IN SURFACE AND LEVELING MIXES AS WELL AS IN BASE MIXES.

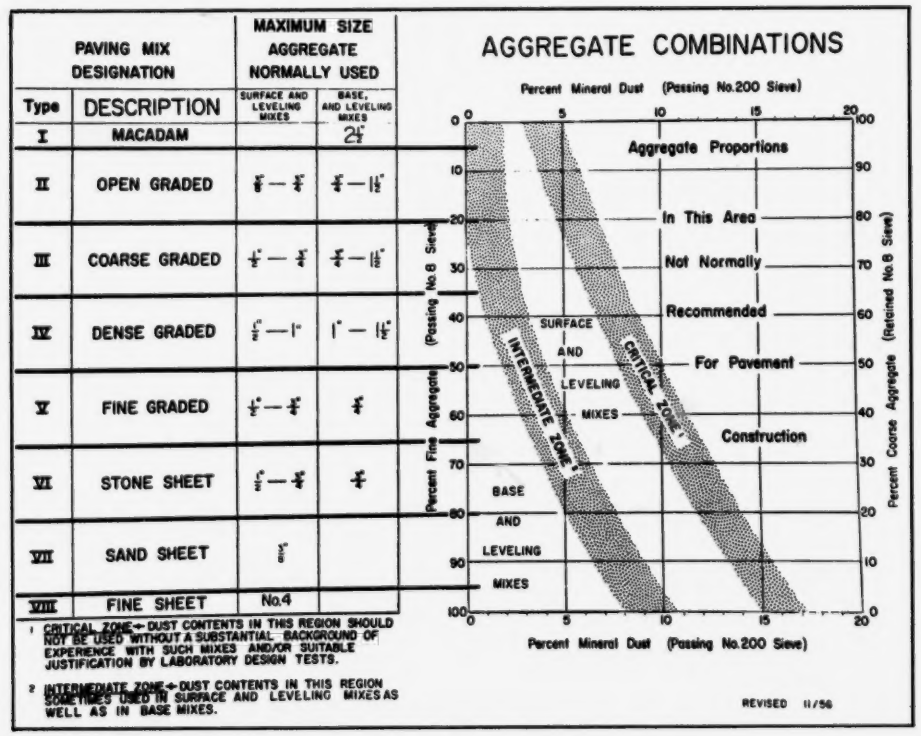


Figure I-1—Classification of Asphalt Paving Mixes

1.04 CONTROL OF ASPHALT APPLICATION TEMPERATURES.—Asphalt is a thermo-plastic material that decreases in viscosity with increasing temperature. The relationship between temperature and viscosity, however, may not be the same for different sources or types and grades of asphaltic material.

Application temperatures are normally specified for various uses of asphaltic materials but, because of these viscosity variations, the specification of temperature *alone* is inadequate for their most effective use. Therefore, The Asphalt Institute recommends that the temperature-viscosity relationship *, determined and furnished by the asphalt producer for each asphaltic material, must be taken into consideration to arrive at the proper viscosity for the construction process being used.

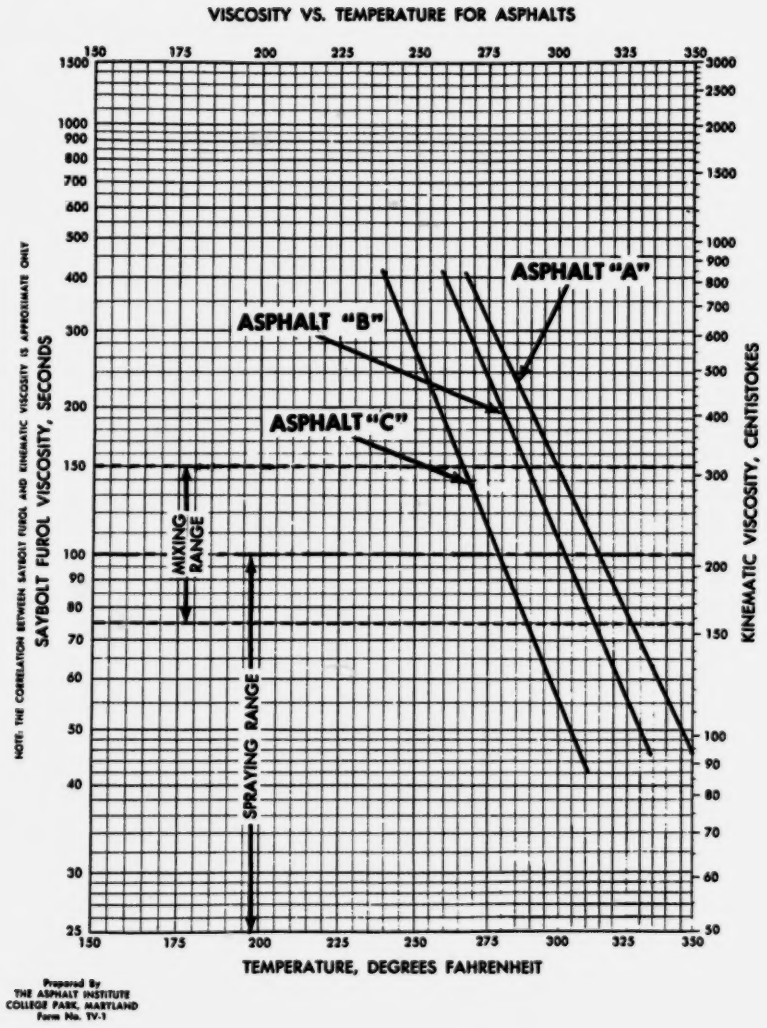
The most suitable application viscosity will depend upon such factors as:

(1) Type of application
(2) Characteristics and gradation of aggregate
(3) Weather conditions

Because of these variables, the proper viscosity for a specific application must be established by trial. The highest viscosity (lowest temperature) should be selected that will insure adequate coating of the aggregate and proper workability for placing and compacting the mix.

Generally the most effective temperature for plant mixing, particularly for Mix Types IV, V, VI, VII and VIII, is that which will yield viscosities in the range of 150-300 centistokes (75-150 seconds Saybolt Furol). Mixing and placing of Mix Types I, II and III can often be adequately accomplished at higher viscosities than those given above. In fact, it is recommended that types I and II be mixed at viscosities of 300-1600 centistokes (150-800 seconds Saybolt Furol) to prevent drainage of the asphalt during transit. However, no mixes should be made at temperatures below 225°F. Current viscosity

**A chart, Asphalt Institute Form No. TV-1, is available from the Institute for plotting these data (See Figure I-2).*



NOTE: The above chart illustrates temperature-viscosity characteristics for three asphalt cements, all of the 85-100 penetration grade.

Figure I-2—Viscosity vs. Temperature for Asphalts

data should be available at the plant at all times to aid in determining the proper temperature of the completed batch. Using the viscosity information, the engineer should designate the temperature of the completed mix at the plant and at the paver. Since the bulk of any mix is the aggregate, the temperature at which it is introduced into the mixer controls the mixing temperatures.

In the absence of suitable temperature-viscosity data, the following tabulation provides a guide for use in determining application temperatures:

GRADE OF ASPHALT CEMENT	Suggested Mixing Temperature
40-50 pen	300-350°F
60-70 pen	275-325°F
85-100 pen	275-325°F
120-150 pen	275-325°F
200-300 pen	225-275°F

Chapter II

PROCEDURES FOR DEVELOPING SPECIFICATIONS

A. Engineering Survey and Analysis

2.01 GENERAL.—It is the engineer's responsibility to make a complete survey and analysis of the special requirements of each paving project and to record such information in an Engineering Report. This report should include references to methods and authorities used by the engineer in developing decisions.

The main purpose of the report is to provide:

(1) A record of local conditions which will influence the specifications

(2) A systematic method for preparing the specifications

(3) A basis for sound engineering decisions

In designing hot-mix asphalt paving, first consideration should be given to local conditions which may influence cost and performance. The following is a list of local factors affecting design:

(1) **SURVEY**

(a) *Traffic*
(b) *Climate*
(c) *Soils*
(d) *Aggregates*
(e) *Asphalts*
(f) *Available Skilled Labor*
(g) *Available Equipment*
(h) *Economic Factors*

(2) **DESIGN**

(a) *Location*
(b) *Drainage*
(c) *Materials Testing*
(d) *Thickness*
(e) *Plans*
(f) *Specifications*

(3) **CONSTRUCTION**

(a) *Earth Work*
(b) *Subgrade*
(c) *Improved Subgrade*
(d) *Subbase*
(e) *Base*
(f) *Asphalt Surface*
(g) *Paved Shoulders*

A suggested work form titled, "Proposal and Preliminary Engineering Report for the Construction of Asphalt Paving," appears in Appendix B.

B. Preparation of Specifications

2.02 GENERAL.—The following information may be used by the engineer to formulate the various design features which he recommends in his Engineering Report:

(1) Thickness Design
(2) Comparison of Aggregate Gradations
(3) Designation of Asphalt Grade and Content
(4) Mix Design Method
(5) Composition of Mixes

As he prepares his specification, the engineer should constantly bear in mind that the objective of any specification is to achieve a workable procedure according to established standards of quality and uniformity. He should also be alert to the economical use of materials, equipment and construction know-how.

2.03 THICKNESS DESIGN.—Methods for determining the thickness of surface, base and subbase are contained in *Thickness Design—Asphalt Pavement Structures for Highways and Streets,* Manual Series No. 1 (MS-1), The Asphalt Institute. This booklet presents in detail, procedures for traffic analysis, materials analysis, alternate designs, economic analysis and selection of design, together with compaction requirements and a section listing typical examples illustrating the various thickness design formulas.

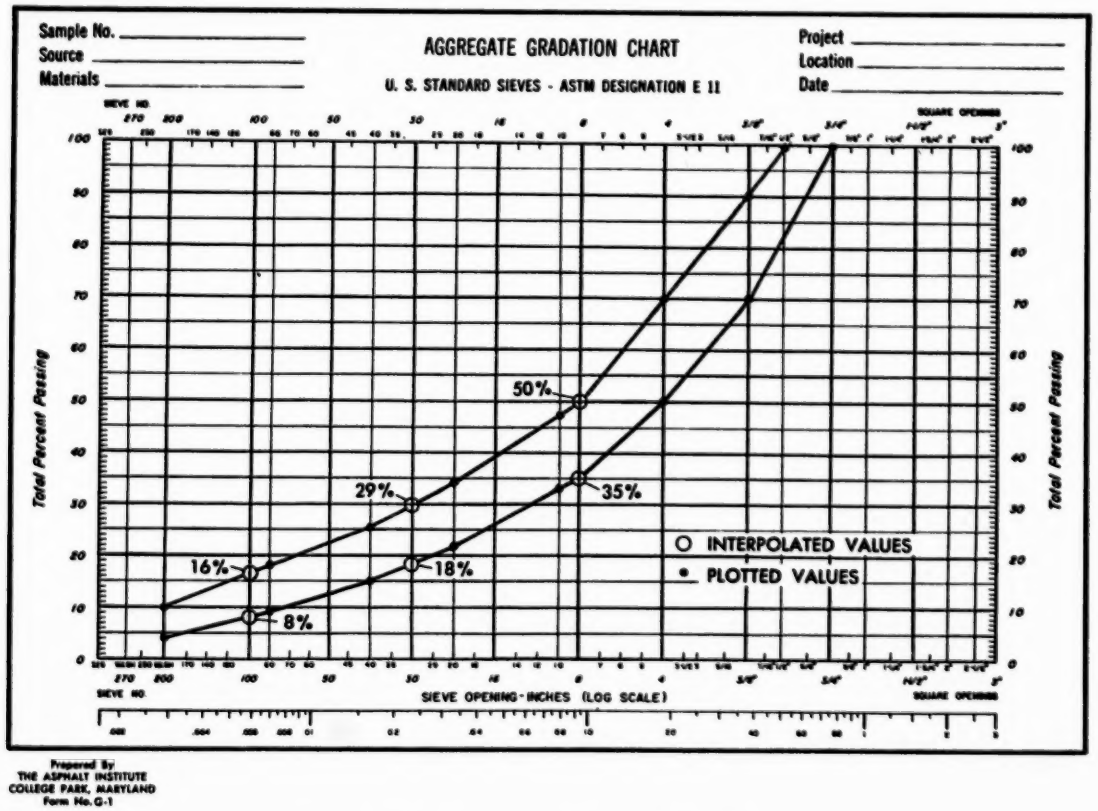


Figure II-1—Aggregate Grading Chart

2.04 COMPARISON OF AGGREGATE GRADATION.—Comparison of mixes recommended by various organizations is often difficult because of different methods of expressing aggregate gradations. There are two standard sieve series and two methods of showing the relative proportions of the several sizes of aggregates.

The Asphalt Institute has adopted the sieve series using the following square sieve opening—2½ in., 1½ in., 1 in., ¾ in., ½ in., ⅜ in., No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200. In mixes with a low percentage of fine aggregate, the No. 100 sieve is considered of little importance in the total gradation.

Standard aggregate charts usually show a parallel scale for each sieve series, and conversion from one sieve size to another may be made by interpolation, i.e., by plotting the gradation and circling the points on the chart representing the desired sieve sizes. This is illustrated in Figure II-1.

Aggregate gradations are expressed by two methods: (1) total percent passing or, conversely, total percent retained method; and (2) the so-called "passing and retained" method wherein the percentage range passing each sieve size and retained on the next smaller sieve is specified.

The Asphalt Institute has adopted the "total percent passing" method.

The "total percent passing" method is easily converted to "total percent retained" by subtracting from 100 the figure shown for each sieve size.

Values in the "passing and retained" method may be converted to approximately equivalent values in "total percent passing" method by making a tabulation and following the steps indicated in Table II-1.

2.05 DESIGNATION OF ASPHALT GRADE, CONTENT.—Selection of the proper grade of asphalt cement is important. The grade performing most satisfactorily on local projects of similar aggregate gradations and traffic conditions should receive first consideration. The recommendations in Table II-2 are intended

TABLE II-1—AN APPROXIMATE PROCEDURE FOR TRANSFORMING "PASSING-RETAINED" SPECIFICATION TO AN EQUIVALENT "TOTAL PERCENT PASSING" SPECIFICATION.

Assumed "Passing-Retained" Specification				Step 1		Step 2		Step 3		Step 4	
Passing	Retained	Percent Total Material	Sieve Size	Cumulative Percent Passing, Fine to Coarse Sizes		Cumulative Percent Retained, Coarse to Fine Sizes		Cumulative Percent Passing, Coarse to Fine Sizes		Equivalent Specification on "Total Percent Passing" Basis*	
				Min.	Max.	Min.	Max.	Min.	Max.		
Col. No. 1	Col. No. 2	Col. No. 3 4	Col. No. 5	Col. No. 6	Col. No. 7	Col. No. 8	Col. No. 9	Col. No. 10	Col. No. 11	Col. No. 12	Col. No. 13
			1½ in.	63	100+						
1½ in.	1 in.	0 — 18	1 in.	63	100+	0	18	100	82	82 —	100
1 in.	¾ in.	4 — 11	¾ in.	59	100+	4	29	96	71	71 —	96
¾ in.	⅜ in.	5 — 12	⅜ in.	54	93	9	41	91	59	59 —	91
⅜ in.	⅛ in.	3 — 9	⅛ in.	51	84	12	50	88	50	51 —	84
⅛ in	# 4	9 — 13	# 4	42	71	21	63	79	37	42 —	71
# 4	# 8	10 — 14	# 8	32	57	31	77	69	23	32 —	57
# 8	# 16	8 — 12	# 16	24	45	39	89	61	11	24 —	45
# 16	# 30	7 — 11	# 30	17	34	46	100+	54	0	17 —	34
# 30	# 50	6 — 10	# 50	11	24	52	100+	48	0	11 —	24
# 50	# 100	5 — 9	# 100	6	15	57	100+	43	0	6 —	15
# 100	# 200	4 — 8	# 200	2	7	61	100+	39	0	2 —	7
# 200		2 — 7									

Notes: COLUMN 5 is the same as Column 2 repeated for convenience and clarity
COLUMN 6 is derived by adding the values in Column 3 from Fine to Coarse
COLUMN 7 is derived by adding the values in Column 4 from Fine to Coarse
COLUMN 8 is derived by adding the values in Column 3 from Coarse to Fine
COLUMN 9 is derived by adding the values in Column 4 from Coarse to Fine
COLUMN 10 is derived by subtracting the values in Column 8 from 100 (i.e. Column 10=100—Column 8).
COLUMN 11 is derived by subtracting the values in Column 9 from 100 (i.e. Column 11=100—Column 9).
The values for COLUMN 12 are obtained by selecting whichever value is the larger from either Column 6 or Column 11 (i.e. Column 12=Maximum value from Column 6 and Column 11).
The values for COLUMN 13 are obtained by selecting whichever value is the smaller from either Column 7 or Column 10 (i.e. Column 13=Minimum value from Column 7 and Column 10).

Where more or fewer screen sizes are used, Columns 3, 4 and 5 would be changed accordingly.

Generally, rounded figures are used as specification limits in Columns 3 and 4 and in Columns 12 and 13. The figures used in this table were selected to indicate more clearly the method.

*It will be noted that a very narrow specification by the "Passing and Retained" method gives a much wider Specification by the "Total Percent Passing" Method. This ability of the "Total Percent Passing" method to provide a narrow close control on the gradation, with reasonable margins on the screen sizes, is an important advantage of this method.

only for the engineer's general guidance where local experience does not provide an adequate basis for the selection of the proper grade of asphalt.

(1) **Proportioning Asphalt.** In the proportioning of paving mixes, it is important to note that there are two methods of specifying asphalt content—"percent by weight of total mix" or "percent by weight of dry aggregate."

TABLE II-2—SUGGESTED PENETRATION GRADES OF ASPHALT CEMENT FOR VARIOUS PAVING USES AND CLIMATIC CONDITIONS

PAVING USES	CLIMATE	
	Hot and Temperate	*Cold*
Airfields		
Runways	60-70	120-150
Taxiways	60-70	85-100
Parking Aprons	60-70	85-100
Highways		
Heavy Traffic	60-70	85-100
Medium to Light Traffic	85-100	120-150
Streets		
Heavy Traffic	60-70	85-100*
Medium to Light Traffic	85-100	85-100
Driveways		
Industrial	60-70	85-100
Service Station	60-70	85-100
Residential	60-70	85-100
Parking Lots		
Industrial	60-70	60-70
Commercial	60-70	85-100
Recreational		
Tennis Courts	85-100	85-100
Playgrounds	85-100	85-100
Curbing	60-70	85-100

** 60-70 penetration normally used for sheet asphalt (Type VIII Mixes).*

The engineer should be alert to this distinction in the completion of the mix composition portion of the specifications and in the comparison and review of local practice.

If "percent by weight of *total mix*" is used and an asphalt content of 6.0 percent is indicated, a 100-lb. sample will contain 6 lbs. of asphalt and 94 lbs. of dry aggregate. In this case an equivalent asphalt content based on weight of dry aggregate is $\frac{6}{94}$ x 100 or 6.38 percent asphalt by weight of dry aggregate.

If "percent by weight of *dry aggregate*" is used and an asphalt content of 6.0 percent is indicated, then 6 lbs. of asphalt are combined with 100 lbs. of dry aggregate to produce a total mix weight of 106 lbs. An equivalent asphalt content based on the total weight of mix would be $\frac{6}{106}$ x 100 or 5.66 percent by weight of total mix. The "percent by weight of total mix" is the preferred method; however, either method may be used provided it is clearly understood by all persons concerned.

(2) **Asphalt Content.** The range of asphalt content should be indicated for each of the mix compositions selected for the specifications. This range should ordinarily be determined in accordance with the specified mix design method. It is often necessary to complete the specifications before a preliminary mix design has been made. In this case, the asphalt content normally is based on the use of relatively non-absorptive aggregates with a bulk specific gravity of 2.65. Corrections, as described in *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types,* Manual Series No. 2 (MS-2), The Asphalt Institute, should be made later for variations.

In case the specifications do not provide for a mix design method, the range of asphalt content may be determined directly from values shown for the mix

type. The range of asphalt content for each mix designated should be within fairly narrow limits.

In any event, the asphalt content of the final job-mix formula can only be determined from experience or after the asphalt plant is in regular operation and the characteristics of the production mix have been established on the job.

2.06 MIX DESIGN METHOD.—For completion of the specifications, "Special Requirements" in Section C, Chapter III, provides for the insertion of test requirements for the total paving mix. The completion of this portion of the specification involves the selection of a mix design method and applicable design criteria. Here the engineer should again review local practice with regard to mix design and the standard mix design methods in general use. The Asphalt Institute publication, *Mix Design Methods* (MS-2), sets forth detailed outlines of test procedures for three widely used methods of hot-mix paving design—the Marshall (ASTM Designation D 1559, *Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus*), the Hubbard-Field (AASHO Designation T 169, ASTM Designation D 1138), and the Hveem (ASTM Designation D 1560, *Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus,* and ASTM Designation D 1561, *Preparation of Test Specimens of Bituminous Mixtures by Means of California Kneading Compactor*).

Table II-3 is a guide to the suitability of a specific mix design method for each of the eight types of mixes. Table II-4 lists suggested criteria for test limits applicable to each traffic classification.

2.07 COMPOSITION OF MIXES.—The eight mix types (Table II-5 through II-12) cover the range of mixes in general use, from macadam types through graded aggregate types to sand and sheet asphalt types.

Of these, the Type IV Mixes (Table II-7) are recommended without qualifications for use in pavement courses for all traffic classifications. Criteria for their use have been established by extensive field and laboratory tests and are the basis for the recommended design

TABLE II-3—SUITABILITY OF LABORATORY DESIGN METHODS

PAVING MIX TYPE AND DESCRIPTION	HUBBARD-FIELD	MARSHALL	HVEEM
I Macadam	X	X	X
II Open Type	X	X	D
III Coarse Graded	X	D	A
IV Dense Graded	X	A	A
V Fine Graded	X	A	A
VI Stone Sheet	A	A	A
VII Sand Sheet (Sand Asphalt)	A	A	A
VIII Fine Sheet (Sheet Asphalt)	A	A	A

A—Suitable
D—Doubtful
X—Unsuitable

thicknesses and substitution ratios set forth in Asphalt Institute publications, such as *Thickness Design* (MS-1).

There are qualifications and limitations regarding the use of the other seven mix types which are set forth in the tables. All of these types are being used successfully in various localities, although a given type which is very suitable for use in one locality may not be the type best suited for another.

In widespread use as surface courses, these asphalt paving mixes are being used more and more by engineers as base courses. Asphalt base courses provide the constant strength necessary to meet all subgrade moisture conditions.

Mix type selection should be based upon availability of suitable aggregates, desired pavement characteristics, and past performance of similar pavements. The use of a new mix type should be carefully checked in the laboratory prior to its adoption.

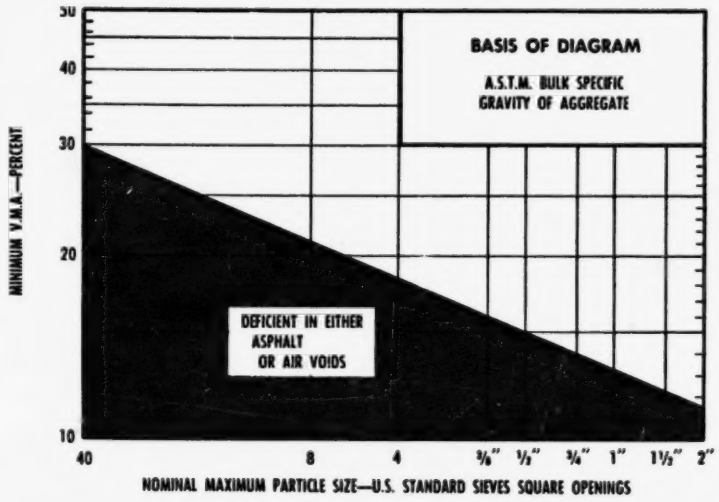


Figure II-2—Relationship Between Minimum V.M.A. and Nominal Maximum Particle Size of the Aggregate for Compacted Dense-Graded Paving Mixtures

When mix Types I, II or III are to be laid over a plastic subgrade course, they should have a blanket, not less than two inches thick, of screenings or clean sand to prevent intrusion of the plastic material into the asphalt base course.

(1) **"Skip-Graded" Mixes.** Mix Types I through VIII are based on graded aggregates falling within relatively narrow grading bands. There are, however, known examples where the use of "skip-graded" aggregates have provided satisfactory pavements with lengthy service records.

So called "skip-graded" mixes usually are dense mixes designed to develop maximum interlock of the coarse aggregate particles and which depend largely on this interlock for stability. To accomplish this, a sand or fine aggregate of a top size that will not bulk the coarse aggregate is normally used. The mix is so proportioned that the fine aggregate acts as a mortar filling the voids in the coarse aggregate, but not bulking it sufficiently to affect interlock.

Specification grading bands for this type of mix must necessarily be broad. The job-mix formula set

TABLE II-4—SUGGESTED CRITERIA FOR TEST LIMITS*

Design Method	Heavy Traffic**		Medium Traffic**		Light Traffic**	
	Min.	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*
Marshall						
Number of compaction blows, each end of specimen	75		50		35	
Stability, all mixtures	750	——	500	——	500	——
Flow, all mixtures	8	16	8	18	8	20
% Air Voids						
Surfacing or Leveling	3	5	3	5	3	5
Sand or Stone Sheet	3	5	3	5	3	5
Sand Asphalt	5	8	5	8	5	8
Base	3	8	3	8	3	8
% Voids in Mineral Aggregate						
Surfacing or Leveling			See Figure II-2			
Sand or Stone Sheet			See Figure II-2			
Sand Asphalt			See Figure II-2			
Base			See Figure II-2			
Hubbard-Field						
Original Method						
Stability, lbs.	2000	——	1200	2000	1200	2000
% Air Voids	2	5	2	5	2	5
Hveem						
Stabilometer	37	——	35	——	30	——
Cohesiometer	50	——	50	——	50	——
Swell, inches	——	.03	——	.03	——	.03
% Voids ***	4	——	4	——	4	——

**Criteria applicable only when testing is done in conformance with methods outlined in Asphalt Institute publication,* Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, *Manual Series No. 2. All criteria, not stability value alone, must be considered in designing an asphalt paving mix.*

***See* Thickness Design, Asphalt Pavement Structures for Highways and Streets, *Manual Series No. 1 for details of traffic classifications.*

****Although not a routine part of the design method, an effort is made to provide a minimum of 4% air voids.*

within these bands should be adhered to in the tolerances outlined in Section C, Chapter III.

These mixes can be placed to a very uniform textured surface using machine methods, but they have a tendency to segregate if hand placing is not performed skillfully. All construction and inspection procedures must be very closely controlled.

The three mixes noted in Table II-14 are examples of the "skip-graded" type.

TABLE II-5—COMPOSITION OF TYPE I MIX
(Macadam Type)

MIX NO.	Ia
USE	Base
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	3 in.-4 in.
SIEVE SIZES (SQUARE OPENINGS)	Percent Passing By Weight
2½ in.	100
1½ in.	35—70
1 in.	—
¾ in.	0—15
½ in.	—
⅜ in.	—
# 4	—
# 8	0—5
# 30	—
# 100	—
# 200	0—3

Normal asphalt content 3.0-4.5% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications: *For all light and medium traffic classifications.*

Traffic Limitations: *Not recommended for heavy traffic classifications.*

Surface Texture: *Very open and porous (requires surface course.)*

Aggregate Required: *Sound, angular crushed stone, crushed gravel, or crushed slag and fine aggregate.*

TABLE II-6—COMPOSITION OF TYPE II MIXES
(Open Graded)

MIX NO.	IIa	IIb	IIc	IId	IIe
Use	Plant-Mix Surface Treatment	Surface Plant-Mix Surface Treatment	Surface	Base	Base
Compacted Depth Recommended for Individual Courses	⅜ in.-¾ in.	¾ in.-1½ in.	1 in.-2 in.	1½ in.-3 in.	3 in.-4 in.
Sieve Sizes (Square Openings)	Percent Passing By Weight				
1½ in.					100
1 in.				100	70—100
¾ in.			100	70—100	50—80
½ in.		100	70—100	—	—
⅜ in.	100	70—100	45—75	35—60	25—50
# 4	40—85	20—40	20—40	15—35	10—30
# 8	5—20	5—20	5—20	5—20	5—20
# 30	—	—	—	—	—
# 100	—	—	—	—	—
# 200	0—4	0—4	0—4	0—4	0—4

Normal asphalt content 3.0-6.0% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications: *For all light and medium traffic classifications.*

Traffic Limitations: *Not recommended for heavy traffic classifications.*

Aggregate Required: *Sound, angular crushed stone, crushed gravel, crushed slag and fine aggregate.*

TABLE II-7—COMPOSITION OF TYPE III MIXES

(Coarse Graded)

MIX NO.	IIIa	IIIb	IIIc	IIId	IIIe
USE	Surface	Surface or Leveling	Base	Base	Base
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	¾ in.-1½ in.	1 in.-2 in.	1 in.-2 in.	1½ in.-3 in.	3 in.-4 in.
SIEVE SIZES (SQUARE OPENINGS)	Percent Passing By Weight				
1½ in.					100
1 in.				100	75—100
¾ in.		100	100	75—100	60—85
½ in.	100	75—100	75—100	—	—
⅜ in.	75—100	60—85	60—85	45—70	40—65
# 4	35—55	35—55	30—50	30—50	30—50
# 8	20—35	20—35	20—35	20—35	20—35
# 30	10—22	10—22	5—20	5—20	5—20
# 50	6—16	6—16	3—12	3—12	3—12
# 100	4—12	4—12	2—8	2—8	2—8
# 200	2—8	2—8	0—4	0—4	0—4

Normal asphalt content 3.0-6.0% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications: *For light, medium and heavy traffic classifications.*

Traffic Limitations: *Mix Types IIIa, IIIb, and IIIc are not recommended for heavy traffic classifications.*

Surface Texture: *Open—medium to coarse.*

Aggregate Required: *Sound, angular crushed stone, crushed gravel or crushed slag, and fine aggregate.*

TABLE II-8—COMPOSITION OF TYPE IV MIXES

(Dense Graded)

MIX NO.	IVa	IVb	IVc	IVd
USE	Surface	Surface	Surface or Base	Base
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	¾ in.-1½ in.	1 in.-2 in.	1½ in.-3 in.	2½ in.-4 in.
SIEVE SIZE (SQUARE OPENINGS)	Percent Passing By Weight			
1½ in.				100
1 in.			100	80—100
¾ in.		100	80—100	70—90
½ in.	100	80—100	—	—
⅜ in.	80—100	70—90	60—80	55—75
# 4	55—75	50—70	48—65	45—62
# 8	35—50	35—50	35—50	35—50
# 30	18—29	18—29	19—30	19—30
# 50	13—23	13—23	13—23	13—23
# 100	8—16	8—16	7—15	7—15
# 200	4—10	4—10	0—8	0—8

Normal asphalt content 3.5-7.0% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Type IV Mixes are recommended for all applications; i.e. for asphalt paving courses for all traffic classifications.

Traffic Limitations: *None.*

Surface Texture: *Medium to fine.*

Aggregate Required: *Sound, angular crushed stone, crushed gravel or crushed slag, and fine aggregate.*

TABLE II-9—COMPOSITION OF TYPE V MIXES

(Fine Graded)

MIX NO.	Va	Vb
USE	Surface	Surface or Leveling *
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	¾ in.-1½ in.	1 in.-2 in.
SIEVE SIZES (SQUARE OPENINGS)	*Percent Passing By Weight*	
¾ in.	—	100
½ in.	100	85—100
⅜ in.	85—100	—
# 4	65—80	65—80
# 8	50—65	50—65
# 16	37—52	37—52
# 30	25—40	25—40
# 50	18—30	18—30
# 100	10—20	10—20
# 200	3—10	3—10

Normal asphalt content 4.0 - 7.5% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications:

Surface: General utility mix. Often used for streets and highways, driveways, parking lots, and playgrounds. Widely used where coarse aggregates are scarce or expensive.

Leveling: For leveling of uneven bases.

Traffic Limitations: *For heavy traffic, the finer grades of the mix type tend to be somewhat sensitive to variations in proportioning and may become critical. Thorough laboratory testing necessary before being used for heavy traffic classifications.*

Surface Texture: *Dense and gritty.*

Aggregate Required: *Hard, sound, angular crushed stone, crushed gravel or crushed slag, and fine aggregate.*

* *May be used for base where coarse aggregate is not economically available.*

TABLE II-10—COMPOSITION OF TYPE VI MIXES

(Stone Sheet)

MIX NO.	VIa	VIb
USE	Surface	Surface or Leveling*
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	1 in.-2 in.	1 in.-2 in.
SIEVE SIZES (SQUARE OPENINGS)	*Percent Passing By Weight*	
¾ in.		100
½ in.	100	—
⅜ in.	85—100	85—100
# 4	—	—
# 8	65—80	65—80
# 16	50—70	47—68
# 30	35—60	30—55
# 50	25—48	20—40
# 100	15—30	10—25
# 200	6—12	3—8

Normal asphalt content 4.5 - 8.5% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications:

Surface: For city streets, playgrounds, tennis and game courts, driveways, parking ramps, and industrial floors. Used for roads where coarse aggregates are scarce or expensive.

Leveling: *For leveling of uneven bases.*

Traffic Limitations: *Thorough laboratory testing necessary before being used for heavy traffic classifications.*

Surface Texture: *Dense and gritty.*

Aggregate Required: *Well graded. Moderately sharp to sharp sands are preferable.*

* *May be used for base where coarse aggregate is not economically available.*

TABLE II-11—COMPOSITION OF TYPE VII MIXES

(Sand Sheet)

MIX NO.	VIIa
USE	Surface*
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	½ in.-1 in.
SIEVE SIZES (SQUARE OPENINGS)	*Percent Passing By Weight*
⅜ in.	100
# 4	85—100
# 8	80—95
# 16	70—89
# 30	55—80
#50	30—60
# 100	10—35
# 200	4—14

Normal asphalt content 7.0 - 11% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Applications: *As a surface on city streets and highways where coarse aggregates are not economically available.*

Traffic Limitations: *Thorough laboratory testing necessary before being used for heavy traffic classifications.*

Surface Texture: *Dense and gritty.*

Aggregate Required: *Well graded. Moderately sharp to sharp sand preferable.*

** May be used for base where coarse aggregate is not economically available.*

TABLE II-12—COMPOSITION OF TYPE VIII MIXES

(Fine Sheet)

MIX NO.	VIIIa
USE	Surface
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	½ in.-1½ in.
SIEVE SIZES (SQUARE OPENINGS)	*Percent Passing By Weight*
# 4	100
# 8	95—100
# 16	85—98
# 30	70—95
# 50	40—75
# 100	20—40
# 200	8—16

Normal asphalt content 7.5 - 12.0% by weight of total mix. Upper limit may be raised when using absorptive aggregate.

Usual Application: *As a surface on city streets where coarse aggregates are not economically available.*

Traffic Limitations: *Thorough laboratory testing necessary before being used for heavy traffic classifications.*

Aggregate Required: *Well graded, sharp sand with inherent stability.*

TABLE II-13—COMPILATION OF MIX TYPES

Mix Number	2½ in.	1½ in.	1 in.	¾ in.	½ in.	⅜ in.	No 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	Percent Asphalt
Ia	100	35-70		0-15				0-5					0-3	3.0-4.5
IIa						100	40-85	5-20					0-4	3.0-6.0
IIb					100	70-100	20-40	5-20					0-4	3.0-6.0
IIc				100	70-100	45-75	20-40	5-20					0-4	3.0-6.0
IId			100	70-100		35-60	15-35	5-20					0-4	3.0-6.0
IIe		100	70-100	50-80		25-50	10-30	5-20					0-4	3.0-6.0
IIIa					100	75-100	35-55	20-35		10-22	6-16	4-12	2-8	3.0-6.0
IIIb				100	75-100	60-85	35-55	20-35		10-22	6-16	4-12	2-8	3.0-6.0
IIIc				100	75-100	60-85	30-50	20-35		5-20	3-12	2-8	0-4	3.0-6.0
IIId			100	75-100		45-70	30-50	20-35		5-20	3-12	2-8	0-4	3.0-6.0
IIIe		100	75-100	60-85		40-65	30-50	20-35		5-20	3-12	2-8	0-4	3.0-6.0
IVa					100	80-100	55-75	35-50		18-29	13-23	8-16	4-10	3.5-7.0
IVb				100	80-100	70-90	50-70	35-50		18-29	13-23	8-16	4-10	3.5-7.0
IVc			100	80-100		60-80	48-65	35-50		19-30	13-23	7-15	0-8	3.5-7.0
IVd		100	80-100	70-90		55-75	45-62	35-50		19-30	13-23	7-15	0-8	3.5-7.0
Va					100	85-100	65-80	50-65	37-52	25-40	18-30	10-20	3-10	4.0-7.5
Vb				100	85-100		65-80	50-65	37-52	25-40	18-30	10-20	3-10	4.0-7.5
VIa					100	85-100		65-80	50-70	35-60	25-48	15-30	6-12	4.5-8.5
VIb				100		85-100		65-80	47-68	30-55	20-40	10-25	3-8	4.5-8.5
VIIa						100	85-100	80-95	70-89	55-80	30-60	10-35	4-14	7.0-11.0
VIIIa							100	95-100	85-98	70-95	40-75	20-40	8-16	7.5-12.0

NOTE

For curb mix composition refer to the Asphalt Institute's *Specification and Construction Methods for Asphalt Curbs and Gutters*, Specifications Series No. 3 (SS-3).

For mix compositions for hydraulic applications refer to Asphalt Institute's *Asphalt in Hydraulic Structures* (MS-12).

TABLE II-14—COMPOSITION OF SKIP-GRADED MIXES

MIX NO.	Skip A	Skip B	Skip C
USE	Surface or Leveling	Leveling, or Base	Base
SIEVE SIZES (SQUARE OPENINGS)	*Percent Passing By Weight*		
2 in.			100
1½ in.		100	95—100
1 in.		95—100	—
¾ in.	100	—	60—80
½ in.	95—100	60—80	—
# 4	50—70	30—50	25—45
# 8	30—50	20—40	15—35
# 50	5—25	5—25	3—20
# 200	2—10	1—10	0—5

Normal asphalt content 4.0 - 9.0% by weight of total mix.
Upper limit may be raised when using absorptive aggregate.

Chapter III

CONSTRUCTION SPECIFICATIONS FOR ASPHALT CONCRETE AND OTHER PLANT-MIX TYPES

NOTE TO THE ENGINEER:* This part of the manual presents specifications for asphalt concrete (or plant-mix) paving. High quality paving mixes require adherence to the following:

Proper mix design and control by laboratory methods;

Use of quality aggregates;

Close limits for aggregate grading;

Close job tolerances;

Strict requirements for mixing plants and well-adjusted and operated construction equipment;

Specific compaction (density) requirements;

Specific smoothness requirements;

Strict engineering inspection and control.

Before using these specifications definite requirements or limits, selected or determined by design, should be inserted in those places where it is indicated.

See Appendix C for charts showing possible causes of deficiencies in hot plant-mix paving mixtures and possible causes of imperfections in finished pavements.

A. Description

3.01 GENERAL.—The paving mix shall be composed of mineral aggregate and asphalt cement thoroughly mixed, in a plant meeting the requirements of

* "Notes to the Engineer" found in these specifications are for the Engineer's information only and do not form a part of the general instruction. These references are boxed.

these specifications, until all aggregate particles are coated completely with asphalt. The finished pavement shall conform in all respects with lines, grades, dimensions and cross sections shown on the project plans.

3.02 MIX NUMBERS AND THICKNESSES.—The paving mix shall be laid in _____ course(s). The Mix Number designation and compacted average thickness of each course shall be as follows:*

PAVING COURSE	MIX NO.	COMPACTED THICKNESS
Base	_____	_____ inches
Leveling	_____	_____ inches
Sruface	_____	_____ inches

The compacted thickness of any single constructed course shall not exceed three times the largest aggregate size or a maximum of four (4) inches for base course, three (3) inches for leveling course, or two (2) inches for surface course.

3.03 PRIME AND TACK COAT.—Priming of base and applying asphalt tack coat to existing paved surfaces shall be done with the following types of asphalt at the rates specified:**

For Priming Base _____ asphalt
at the rate of _____ gallon per sq. yd.
For Applying Tack Coat _____ asphalt
at the rate of _____ gallon per sq. yd.

* **NOTE TO THE ENGINEER:** *Mix Number Designations correspond with Mix Number to be specified in Article 3.12.*

** **NOTE TO THE ENGINEER:** *Under normal circumstances, these operations may be done with the following materials within the application ranges shown:*

Priming Base: *0.2 to 0.5 gallon of MC-30 per sq. yd.*
Applying Tack Coat: *0.05 to 0.15 gallon of SS-1, SS-1h, SS-K or SS-Kh per sq. yd. In order to apply the above limited quantities uniformly, emulsion is diluted with equal parts of water.*

B. Materials and Tests

3.04 APPROVAL OF MATERIALS.—No material shall be used until it has been checked or tested for compliance with specifications and been approved by the Engineer. Representative samples of all materials proposed for use under these specifications shall be submitted to the Engineer by the Contractor, or at the Contractor's expense, for test and for the preparation of trial mixes to.....* the job-mix formula. All tests necessary to determine conformance with the requirements specified herein will be performed under the supervision of the Engineer without cost to the Contractor.

Asphalt materials shall be approved by the Engineer prior to use in the work, provided, however, that the Engineer may accept a certified analysis by the refinery laboratory when a copy of the certified analysis accompanies each shipment of asphalt to the project. The Engineer will reserve the right to make check tests of the asphalt received on the job and, if the system of certified analysis proves to be unsatisfactory to the Engineer, he may discontinue this arrangement.**

The Contractor or asphalt supplier shall furnish the engineer with data on the temperature-viscosity relationship of each asphalt to be used on the project. These data shall cover the range of temperatures and viscosities within which the asphalt may be used. On the basis

* **NOTE TO THE ENGINEER:** *Insert the word "check" or the word "determine," depending on whether or not the Contractor is to submit the job-mix formula.*

** **NOTE TO THE ENGINEER:** *Appendix D contains supplementary notes on "Sampling Asphalt Products and Specification Compliance" plus pictures and brief descriptions of three asphalt sampling devices which have been successful in use.*

of these data, the Engineer will specify the temperature at which the material shall be used.

The Contractor shall not remove asphalt material from tank cars or storage tanks until the initial outage and temperature measurements have been taken, nor shall he release cars or tanks until the final outage has been taken by the Engineer.

Copies of all freight bills and weigh bills shall be furnished to the Engineer as the work progresses.*

3.05 ASPHALT.—The asphalt required by these specifications or indicated on the plans is as follows:

Asphalt for Paving Mix _____ (type & grade)
Asphalt for Prime Coat _____ (type & grade)
Asphalt for Tack Coat _____ (type & grade)

These materials shall conform to the latest revised *Specifications for Asphalt Cements and Liquid Asphalts,* Specification Series No. 2 (SS-2), The Asphalt Institute, for the type(s) and grade(s) shown above. Sampling shall be in accordance with *Standard Methods of Sampling Bituminous Materials,* AASHO Designation T 40 (ASTM Designation D 140).

3.06 COARSE AGGREGATE.—Coarse aggregate is all mineral material retained on the No. 8 sieve. It shall

* **NOTE TO THE ENGINEER:** *The following requirements may be inserted at this point:*

A log of all loads hauled shall be maintained by the driver for each transport truck so that the type of material that was in the tank previously will be known, if a question of contamination arises.

The Contractor shall provide a ramp at the unloading point at the plant site for use by asphalt transport trucks to assure complete drainage of the tanks while the material is still fluid. The Engineer, or his authorized representative, will inspect the tank and certify on the truck's log that it was completely unloaded on an incline.

Immediately before an asphalt transport truck or railroad tank car is loaded with fresh material it shall be again inspected to be certain it is acceptable for reloading.

consist of crushed stone, crushed slag, crushed gravel, or combinations thereof, or of material naturally occurring in a fractured condition (such as disintegrated granite) or of a highly angular natural aggregate with pitted or rough surface texture. For light and medium traffic classifications, uncrushed aggregate may be used.

Crushed slag shall be air-cooled, blast-furnace slag uniform in density and quality. When tested by Method of Test for Unit Weight of Aggregate, AASHO Designation T 19 (ASTM Designation C 29) it shall have a compacted weight of not less than 70 lbs. per cu. ft. (65 lbs. for 2 inches and larger) for each commercial size used.

All coarse aggregate shall be free from coatings of clay, silt or other objectionable matter and shall not contain clay balls or other aggregations of fine material. The percentage of wear for coarse aggregate used in base or leveling courses shall not be greater than 50 when tested by Method of Test for Abrasion of Coarse Aggregate, AASHO Designation T 96 (ASTM Designation C 131). The percentage of wear of coarse aggregate used in surface course mixes shall not be greater than 40 when so tested.

For heavy traffic classification pavements, coarse aggregate other than slag or naturally occurring rough-textured or pitted-surfaced aggregate shall contain at least 60 percent by weight of crushed pieces having two or more surfaces or faces produced by fracture. Coarse aggregates shall be tested for soundness by Method of Test for Soundness of Aggregates, AASHO Designation

NOTE TO THE ENGINEER: In paving mixtures used for base courses, which are to be covered by surface courses of minimum thickness as required by the Asphalt Institute's manual, Thickness Design (MS-1), the requirement for crushed (fractured or angular) coarse aggregate may be relaxed provided the mixture meets all other design criteria.

T 104 (ASTM Designation C 88) or will have been satisfactorily proved sound through adequate record of service. When tested for soundness, the number of cycles shall be . . . . . , the solution shall be . . . . . , and the maximum loss shall be . . . . . .* Aggregates having known polishing characteristics shall not be used in mixes for the surface course.

3.07 FINE AGGREGATE.—Fine aggregate is all mineral matter passing the No. 8 sieve. It shall consist of natural sand and/or manufactured material derived by crushing of stone, slag, or gravel.

The aggregate particles shall be clean, tough, durable, moderately sharp, and free from coatings of clay, silt or other objectionable matter and shall contain no clay balls or other aggregations of fine material. Fine aggregates shall be tested for soundness by Method of Test for Soundness of Aggregates, AASHO Designation T 104 (ASTM Designation C 88) or shall have a satisfactory soundness record. When tested for soundness the number of cycles shall be . . . . . , the solution shall be . . . . . , the maximum loss shall be . . . . . percent.*

3.08 MINERAL FILLER.—Mineral filler shall consist of finely ground particles of limestone, hydrated lime, portland cement or other non-plastic mineral matter approved by the Engineer. It shall be thoroughly dry and free from lumps. When tested by Method of Test for Sieve Analysis of Mineral Filler, AASHO Designation T 37 (ASTM Designation D 546), it shall meet the following minimum gradation requirements:

* **NOTE TO THE ENGINEER:** *The Engineer should insert in the blank spaces the number of cycles, the solution and percent loss which he desires to be used. The Asphalt Institute recommends the following: Number of cycles, 5; solution, sodium sulphate; maximum loss, 12 percent.*

SIEVE SIZE	PERCENT PASSING BY DRY WEIGHT
30	100
100	90
200	65

Mineral dust consists of all mineral matter which will pass the No. 200 sieve; and hence includes such fine particles as may be in the coarse and fine aggregates as well as the mineral dust portion of the mineral filler. It shall be free from organic matter and clay particles.

3.09 SAMPLING AND TESTING AGGREGATE.—Sampling shall be in accordance with *Standard Method of Sampling Stone, Slag, Gravel, Sand and Stone Block For Use as Highway Material,* AASHO Designation T 2 (ASTM Designation D 75). Gradation analysis shall be by *Standard Method of Test for Amount of Material Finer Than No. 200 Sieve in Aggregate,* AASHO Designation T 11 (ASTM Designation C 117) and *Standard Method of Test For Sieve Analysis of Fine and Coarse Aggregate,* AASHO Designation T 27 (ASTM Designation C 136).

NOTE TO THE ENGINEER: The Asphalt Institute's "Washed Sieve Analysis of Fine and Coarse Aggregate" (described in *Asphalt Plant Manual,* Manual Series No. 3 (MS-3)) may be used in lieu of the two tests above (AASHO T 11 and T 27).

3.10 SAND EQUIVALENT OF COMBINED *MINERAL AGGREGATE.—The* mineral aggregate when combined in the portions required by the job-mix formula shall be tested by the method of test for determining Sand Equivalent AASHO Designation T 176. When so tested, the Sand Equivalent shall not be less than the following values:

Combined aggregate for plant-mix asphalt surface or base courses.....45
Combined aggregate for asphalt concrete for surface and base courses.....50

3.11 ASPHALT PAVING MIXES.—Mixes shall be sampled by Standard Methods of Sampling Bituminous Paving Mixtures, AASHO Designation T 168 (ASTM Designation D 979). The mixes will be tested by Method of Test for Bitumen Content of Paving Mixtures by Centrifuge, AASHO Designation T 164 (ASTM Designation D 1097), and the recovered aggregate will be sieved in accordance with Method of Test for Mechanical Analysis of Extracted Aggregates, AASHO Designation T 30. When recovered asphalt is required for further testing, it will be obtained by Method of Test for Hot Extraction of Asphaltic Materials and Recovery of Bitumen by the Modified Abson Procedure, AASHO Designation T 170 (ASTM Designation D 762).

C. Composition of Mixes

3.12 GENERAL REQUIREMENTS.—Paving mixes prepared under these specifications shall be composed of aggregates and paving asphalt within the limits set forth in the following tabulation:

Paving Course.....	Combined Aggregates, Total Passing, Percent by Weight.
SIEVE SIZE (SQUARE OPENINGS)	**MIX NUMBER ***
2½ in.	
1½ in.	
1 in.	
¾ in.	
½ in.	
⅜ in.	
#4	
#8	
#16	
#30	
#50	
#100	
#200	
Asphalt to be added** (% by weight of total mix)	

NOTE TO THE ENGINEER: The Engineer will insert suitable aggregate gradation limits and limits on asphalt content in this space. These limits may be selected on the basis of information contained in Chapter II, "Procedures for Developing Specifications." One such tabulation should be provided for each mix to be used on the project.

* Mix numbers correspond to those set forth in Article 3.02.
** The upper limit may be raised when absorptive aggregates are used.

The Engineer will _____ a job-mix formula for each mix number within the limits specified above.*

The gradations are applicable for aggregate mixes in which the specific gravity of two or more size fractions does not differ by more than twenty (0.20) points. If the specific gravity of two or more size fractions differs by more than twenty (0.20) points, gradations should be adjusted to an equivalent percentage by volume.**

The maximum permissible variation from the job-mix formula within the specification limits, shall be as follows:

SIEVE SIZE	PERMISSIBLE VARIATION, PERCENT BY WEIGHT OF TOTAL MIX
#4 and larger	5.0
#8	4.0
#30	3.0
#200	1.0
Asphalt	0.3

3.13 SPECIAL REQUIREMENTS.—Laboratory test specimens of paving mixes, combined in the proportions of the job-mix formula, shall be prepared and tested in accordance with the procedures set forth for the

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(Marshall, Hveem or Hubbard-Field)

Method of mix design in The Asphalt Institute manual,

* **NOTE TO ENGINEER:** *Insert the word "approve" or the word "specify," depending on whether or not the Contractor is to submit the job-mix formula.*

** **NOTE TO THE ENGINEER:** *Method for adjusting proportions of aggregates of varying specific gravity may be found in Appendix A of The Asphalt Institute Manual,* Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, *Manual Series No.* 2.

Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, Manual Series No. 2 (MS-2).

Test requirements and criteria for the paving mixes prepared under these specifications shall be as follows:

MIX NO.	CRITERIA FOR TEST LIMITS

NOTE TO THE ENGINEER: Enter in this space the criteria for test limits for each mix in accord with the method of mix design specified above. Suggested criteria for test limits are set forth in Table II–4. In addition, state any special provisions necessary because of the type and quality of local aggregate or because of other local conditions.

D. Equipment

3.14 GENERAL EQUIPMENT REQUIREMENTS.—All equipment furnished by the Contractor shall meet the requirements of this section and shall be maintained in its best mechanical condition. Equipment shall be serviced and lubricated away from the paving site; units that drip fuel, oil and grease shall be removed from the project until such leakage is corrected.

3.15 ASPHALT MIXING PLANTS.—Plants used by the Contractor for preparation of the asphalt paving mix shall conform to all of the conditions under "Requirements for All Plants." All *batch mixing plants* shall meet the additional conditions under "Special Requirements for Batch Type Plants," and all *continuous mixing plants* shall conform to the additional requirements under "Special Requirements for Continuous Mixing Plants."

3.16 REQUIREMENTS FOR ALL PLANTS.—

(1) **Uniformity.** The plants shall be designed, coordinated, and operated to produce a uniform mix within the job-mix tolerances as covered in Section C.

(2) **Equipment for Preparation of Asphalt.** Tanks

for storage of asphalt shall be provided with a device for controlled heating of the material to temperature requirements set forth in the specifications. Heating shall be accomplished so that no flame shall come in contact with the heating tank. A circulating system of adequate size to insure proper and continuous circulation of asphalt between storage tank and mixer during the entire operating period shall be provided. The discharge end of the circulating pipeline shall be kept below the surface of the asphalt in the tank while the pump is in operation. Storage tank capacity shall be sufficient to hold enough asphalt for at least one day's run.

(3) **Cold Aggregate Feeder.** The plant shall be provided with an accurate mechanical means for feeding the mineral aggregate into the dryer to secure a uniform production and a constant temperature. The feeder or feeders shall be capable of delivering, in preset proportions, the maximum number of aggregate sizes required. When more than one cold elevator is used, each shall be fed as a separate unit and the individual controls shall be integrated with a total master control.

(4) **Dryer.** The plant shall include a rotary drum dryer that will continuously agitate the mineral aggregates during the heating and drying process. It shall be capable of continuously supplying aggregate, at the temperature and maximum moisture content specified, to the mixing unit operating at its capacity.

(5) **Screens.** Plant screens capable of separating all aggregates to the sizes required for proportioning, and having normal capacity slightly in excess of the full capacity of the mixer or the dryer, shall be provided. The Contractor shall expose the screens for inspection at the request of the Engineer. The plant screens shall have an efficiency such that the bins shall have not more than the following percentages of undersize and oversize:

BIN NO.	UNDERSIZE-PERCENT	OVERSIZE-PERCENT
1	—	10
2	15	10
3	20	5
4	20	0

These screen tolerances shall not invalidate the job-mix tolerances specified in Article 3.12.*

(6) **Bins.** Bins shall be divided into compartments arranged to insure separate storage of the appropriate fractions of aggregates. Each compartment shall be provided with an overflow pipe that will prevent any backing up of material into other compartments or bins or against the screens. The overflow material shall be wasted. Bins shall be equipped with reliable devices to indicate the level of aggregate, especially in the lower quarter of the bins.

The bin sizes shall be adequate for continuous operation of the plant at rated capacity. When the aggregate size, or mix type, indicates the use of less than four hot bins, the screening efficiency requirement stated in the preceding paragraph (5) shall apply for the number of bins used.

When mineral filler is required, additional dry storage shall be provided and provision shall be made for proportioning it into the mix.

(7) **Asphalt Control Unit.** Means shall be provided to obtain the required percentage of asphalt in the mix within the tolerances specified, either by weighing, metering, or measuring volumetrically. Where the quantity of asphalt is controlled by metering, provision shall be made for the amount of asphalt delivered

* **NOTE TO ENGINEER:** *This separation is based on laboratory sieve sizes and the producer may use any size screen opening which he may select to provide the specified efficiency.*

through the meter to be readily checked by weight. Steam jacketing or other insulation which will maintain the specified temperature of asphalt in pipelines, meters, weigh buckets, spray bars, flow lines or other containers shall be provided.

(8) **Thermometric Equipment.** An armored thermometer reading from 200° to 400°F. shall be fixed in the asphalt feed line at a location near the discharge valve at the mixer unit.

The plant shall be further equipped with an approved dial-scale, mercury-actuated thermometer, a recording electric pyrometer, or other approved thermometric instrument having an accuracy of ±5°F. placed at the discharge chute of the dryer to register automatically, or indicate, the temperature of the heated aggregate. Any thermometric instrument used shall be sensitive to a rate of temperature change not less than 10°F. per minute.

The Engineer shall have the right to test the accuracy of thermometric instruments for better control of asphalt, aggregate and mix temperatures. He may direct the immediate repair or replacement of any instrument yielding inaccurate or inconsistent readings.

(9) **Dust Collector.** The plant shall be provided with a dust collector, designed to waste, or return in a constant and uniform flow to the hot elevator by mechanical means, all or part of the material collected. Prior to permitting the return of such collected dust, the Engineer will examine its characteristics in relation to the mix requirements, and will designate the quantity to be returned.

The plant shall have a mixer cover and such additional housing as may be necessary to insure the proper control of dust.

(10) **Safety Requirements.** Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be provided. All gears, pulleys,

chains, sprockets and other dangerous moving parts shall be well guarded and protected. Ample and unobstructed space for the operator shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading space. This space shall be free from drippings from the mixing platform. A ladder, or platform, shall be so located at the truck loading space to permit easy and safe inspection or sampling of the mix as it is delivered into the truck. Overhead protection shall be provided where necessary.

3.17 SPECIAL REQUIREMENTS FOR BATCH TYPE PLANTS.—

(1) **Plant Scales.** Scales for any weigh box or hopper may be of either the springless dial or beam type and shall be of an established make and design, accurate to 0.5 percent of the indicated load.

Dial scales shall be designed, constructed and installed in such manner as to be free from vibration. All dials shall be so located as to be plainly visible to the operator at all times. The numerals on the dial shall be of such size that they can be read at a distance of 25 feet. The end of the pointer shall be set close to the face of the dial to minimize parallax. The scale shall be provided with adjustable pointers for marking the weight of each material to be weighed into the batch.

When scales are of the beam type, there shall be a tare beam for balancing the hopper and a separate beam for the aggregate from each hot bin. A telltale dial shall be provided that will start to function when the load being applied is within 100 pounds of the weight desired. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action.

Scales for the weighing of asphalt shall conform to the requirements for aggregate scales, except that beam scales shall consist of a full capacity beam and a tare beam. The minimum graduation shall be not

greater than two pounds and there shall be attached a telltale device which will start to function when the load being applied is within 25 pounds of the weight desired. Dial scales for weighing the asphalt shall read to the nearest pound. All scales for weighing the asphalt shall have a capacity of not more than 15 percent of the normal capacity of the mixer.

Scales shall be tested and sealed as often as the Engineer may deem it necessary to insure their accuracy. All weighing equipment shall be well constructed and of a design which will permit easy realignment and adjustment. Weighing equipment that easily gets out of adjustment shall be replaced when so ordered by the Engineer. The Contractor shall provide and have on hand at least ten 50-pound standard weights for frequent testing of all scales. For each scale, a suitable cradle, or platform, shall be provided for applying the test load so that the load is distributed uniformly. The test weights shall be kept clean and stored near the scales.

Volumetric proportioning of heated and screeded aggregates will be permissible provided the volumetric system is standard equipment furnished for the plant. The scales used for checking volumetric proportions shall be accurate within 0.5 percent of the check test load.

(2) **Weigh Box or Hopper.** Equipment shall include a weigh box or hopper, large enough to hold a full batch without hand raking or running over, for accurately weighing each bin size of aggregate. The weigh box or hopper fulcrums and knife edges shall be so constructed that they will not be easily thrown out of alignment. Gates on both bins and hopper shall prevent leakage when they are closed. An interlocking device which prevents the opening of more than one gate at a time shall be provided. Proportioning of aggregates and charging of mixer shall be performed so as to blend the aggregates thoroughly and prevent segregation in the mixer.

Automatic plants may proportion all aggregates by simultaneous measuring if a weigh hopper with a separate compartment for each bin size, calibrated by weight, is used.

(3) **Asphalt Measuring Equipment.** Asphalt measuring equipment provided on the plant shall accurately measure into each batch the required amount of asphalt within a tolerance of plus or minus two pounds.

When an asphalt bucket is used, it shall be a non-tilting type provided with a loose sheet-metal cover. The capacity of the asphalt bucket shall be at least 10 percent in excess of the weight of asphalt required for a one-batch mix. The plant shall have a steam-jacketed, quick-closing, non-dripping, charging valve. The length of the discharge opening or spray bar shall be not less than three-fourths of the length of the mixer and it shall discharge directly into the mixer. The discharge system shall be designed and arranged to deliver the asphalt the full length of the mixer in a thin, uniform sheet or in multiple streams or sprays.

When a volumetric meter is used, it shall automatically meter the asphalt into each batch. The dial to indicate the amount of asphalt shall have a capacity of at least 10 percent in excess of the weight or gallons of asphalt required in one batch. The meter shall be constructed so that it may be locked at any dial setting and will automatically reset to this reading after the addition of asphalt to each batch. The dial shall be in full view of the mixer operator. The flow of asphalt shall be controlled to begin automatically when the dry mixing period is over. All of the asphalt required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of asphalt the full length of the mixer. The section of the asphalt flow line between the charging valve and the spray bar shall be provided with a valve and outlet for checking and testing the accuracy of the meter.

(4) **Mixer Unit for Batch Method.** The plant shall include a batch mixer and a batch capacity of not less than .....pounds.* It shall be capable of producing, uniformly, a mix within the job-mix tolerances established in Article 3.12. Deviation in size of batches will be permitted to provide for mixing batches down to 20 percent below and up to 15 percent above the rated capacity of the mixer, provided the quality of the mix is not impaired.

The clearance of the blades from all fixed and moving parts shall not exceed ¾ inch. The paddles shall be set to insure a completely uniform mixture. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The mixer shall be so constructed as to prevent leakage of contents.

(5) **Time Lock and Batch Counter.** The mixer shall have an accurate time control to lock the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. The time lock shall also lock the asphalt bucket throughout the dry and wet mixing periods. Control of the timing shall be flexible, permitting adjustment of cycles up to three minutes in five second intervals. A mechanical batch counter, designed to register only completely mixed batches, shall be installed.

3.18 SPECIAL REQUIREMENTS FOR CONTINUOUS MIXING PLANTS.—

(1) **Gradation Control Unit.** The plant shall include means for accurately proportioning each bin size of aggregate either by weight or by volumetric measurement.

When gradation control is by volume, the unit shall include a feeder mounted under the bins. Each bin compartment shall have an accurately controlled me-

* **NOTE TO THE ENGINEER:** *The Engineer should specify the minimum size plant or plants which he will require for the project.*

chanically adjustable gate to form an opening for volumetrically measuring the material drawn from it. The opening shall be rectangular and provided with a lock. Indicators shall be provided on each gate to show the gate opening in inches. Mineral filler, if specified, shall be proportioned separately from a hopper equipped with an adjustable feed which may be accurately and conveniently calibrated and which shall be interlocked with the aggregate and asphalt feeds.

(2) **Weight Calibration of Aggregate Feed.** Samples shall be taken and weighed as a means of calibrating gate openings. Material shall be fed out of a bin through the individual opening and bypassed to a leakproof test box. The material from each compartment shall be taken separately. The plant shall be equipped to handle conveniently test samples weighing not less than 200 pounds. A platform scale shall be provided by the Contractor to weigh the test samples to an accuracy of ±0.6 percent of the indicated load.

(3) **Synchronization of Aggregate and Asphalt Feed.** Positive interlocking control shall be assured between the flow of aggregate from the bins and the flow of asphalt from the meter or other proportioning device. This shall be accomplished by interlocking mechanical means or by any positive method approved by the Engineer.

The aggregate bins shall be provided with signal devices and controls which will warn of low levels and which will automatically stop the flow of all aggregate and asphalt to the mixer when the aggregate in any one bin is so low that the feeder will not operate at set capacity. The asphalt storage system shall be provided with signal devices and controls which will warn of low levels of asphalt and which will automatically stop the entire plant operation when the asphalt storage level is lowered to the point of exposing the feed end of the asphalt suction line.

(4) **Mixer Unit for Continuous Method.** The plant shall include a continuous mixer of the twin pugmill type capable of uniformly producing a mix within the job-mix tolerance specified in Section C. The paddles shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The clearance of the paddles from all fixed and moving parts shall not exceed ¾ inch. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge.

3.19 PAVERS AND LAYDOWN MACHINES.—Mechanical self-powered pavers shall be capable of spreading the mix, within the specified tolerances, true to the line, grade, and crown indicated on the plans. A motor patrol, equipped with an automatic blade control, may be used for the leveling course.

Pavers shall be equipped with quick and efficient steering devices and shall be capable of traveling both forward and in reverse. They shall be equipped with hoppers and distributing screws which place the mix evenly in front of adjustable screeds.

The screed shall include any strike-off device operated by cutting, crowding or other action which is effective on mixes at workable temperatures without tearing, shoving or gouging them, and which produces a finished surface of an even and uniform texture. The screed shall be adjustable as to height and crown and shall be equipped with a controlled heating device for use when required. The screed shall strike off the mix to the depth and cross-section specified without the aid of manual adjustment during operation.*

Pavers shall be capable of spreading mixes without segregation or tearing. They shall also be capable of

* **NOTE TO THE ENGINEER:** *The performance of automatic screed controls has been proven and these paver attachments are recommended for obtaining the smoothest pavements.*

placing courses in thicknessses of from ½ inch to at least three inches, and from widths of eight feet to at least 13 feet. Extensions and cut-off shoes shall permit changes in widths by increments of six inches, or smaller.

3.20 ROLLERS.—Rolling equipment shall consist of steel-wheeled rollers and pneumatic-tired rollers described as follows:

(1) *Steel-Wheeled Rollers* may be of three types: three-wheeled rollers, two-axle tandem rollers, and three-axle tandem rollers. These rollers shall be equipped with power units of not less than four cylinders and under working conditions shall develop contact pressures under the compression rolls of 250 to 350 pounds per inch of width. Rollers shall be in good working condition and shall be equipped with a reversing clutch. Rollers shall be equipped with adjustable scrapers to keep the wheel surfaces clean and with efficient means of keeping them wet to prevent mixes from sticking. These surfaces shall have no flat areas, openings or projections which will mar the surface of the pavement.

The three-axle tandem rollers shall be so constructed that, when locked in position for all treads to be in one plane, the roller wheels are held with such rigidity that, if either front or center wheel is unsupported, the other two wheels will not vary from the plane more than ¼ inch.

(2) *Pneumatic-Tired Rollers* shall be self-propelled. The rollers shall be equipped with pneumatic tires of equal size and diameter which are capable of exerting average contact pressures varying from 40 psi to 110 psi by adjusting the ballast and/or tire inflation pressures. The wheels of the roller shall be so spaced that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of ¼ inch overlap of the tracking wheels. The wheels shall oscillate but not wobble. The roller shall be so constructed that the contact pressure shall

be uniform for all wheels, and the tire pressure of the several tires shall not vary more than 5 lbs. per sq. in. Pneumatic-tired rollers shall be constructed with enough ballast space to provide uniform wheel loadings as may be required. The total operating weight and tire pressure of the roller may be varied by order of the Engineer to obtain contact pressures that will result in the required density.*

(3) *Trench Rollers* shall have an auxiliary wheel (or roll) that operates outside the area to be compacted at such a distance from the pavement edge as to cause no damage thereto. It shall be mounted upon an axle that is adjustable in height. The auxiliary wheel (or roll) shall be kept in such adjustment that the compression roll will develop a smooth, compacted surface true to crown and grade. The rollers shall be so constructed that the guiding wheel (or roll) operates either in tandem with the compression roll on the area to be compacted or in tandem with the auxiliary wheel (or roll).

Trench rollers shall be equipped with smoothly operating friction clutches of the reversing type and shall have a smoothly operating brake of ample capacity.

The contact pressure per inch width of compression roll shall be not less than 300 pounds and not greater than 365 pounds. The minimum allowable width of compaction shall be 15 inches.

Trench rollers shall be equipped with adjustable scrapers to keep the rolls clean and with efficient means of wetting the rolls to prevent mixes from sticking to them.

3.21 DISTRIBUTORS.—The pressure distributor used for prime and tack coats shall distribute the required amount of asphaltic material at the specified tem-

* **NOTE TO THE ENGINEER:** *Refer to The Asphalt Institute's* Asphalt Paving Manual, *Manual Series No. 8 (MS-8), for a discussion of tire size, wheel load and inflation pressures.*

perature and in a uniform spray, without atomization. The distributor shall be equipped with pneumatic tires of such size and number that the surface being sprayed will not be rutted or otherwise disturbed. It shall have a bitumeter with a dial visible to the truck driver for maintaining the constant speed required for application at the specified rate.

The pump shall be operated by a separate power unit, or by the truck power unit. It shall have a tachometer with a dial readily visible to the operator, registering gallons per minute passing through the nozzles.

The distributor shall be designed so that the normal width of application shall be not less than 12 feet, with provision for the application of lesser or greater width when necessary.

The distributor shall be equipped and operated so that the asphaltic material shall be circulated or agitated throughout the entire heating process. Means for accurately indicating at all times, the temperature of the asphaltic material shall be provided. The thermometer well shall be so placed as not to be in contact with the heating tube.

3.22 HAUL TRUCKS.—Vehicles used for the transportation of asphalt concrete from the plant to the site of work shall have tight metal bottoms and shall be free from dust, screenings, petroleum oils, volatiles or other mineral spirits which may affect the mix being hauled. Trucks shall be provided with covers of sufficient size and weight to protect the load and to prevent cooling of the upper surface. In cool weather or for long hauls, the entire contact area of each truck bed shall be insulated. The Contractor shall provide haul trucks of such size, speed and condition to insure orderly and continuous operations.

3.23 TRUCK SCALES.—Plant-mix asphalt, paid for by the ton, shall be weighed on platform scales furnished by the Contractor, or on public scales at the Contractor's expense. The scales shall comply with all state laws governing the use of scales and shall be tested and sealed

by an authorized public official, at the expense of the Contractor, as often as the Engineer may deem necessary to insure their accuracy.

3.24 FIELD TESTING LABORATORY.—The Contractor shall provide a laboratory building or room at the plant site for the exclusive use of the Engineer for performing tests, keeping records, and making reports. The building shall have floor space of not less than 140 square feet. It shall have at least two windows, one of which must offer a clear and unobstructed view of the plant operator's platform at all times. It shall be weather-proofed, heated, and ventilated and shall contain a sink with cold running water, electricity, sturdily constructed benches, and tables as required by the Special Provisions. The room and its contents shall be secured by locks and catches and all keys shall be under the control of the Engineer.

3.25 HAND TOOLS.—Only lutes or rakes with covered teeth shall be used during the spreading operation and when finishing by hand.

Tamping irons used to consolidate the edges of the pavement courses shall be of sufficient weight to compact the edges to the same degree as the body of the pavement. Irons shall be designed to form an edge as nearly vertical as possible. Irons which seal the material by heat alone shall not be used. Tamping irons used to consolidate the material along curbs, gutters and other structures inaccessible to the roller shall weigh not less than 25 pounds and shall have a bearing area not exceeding 48 square inches. Mechanical compaction equipment, approved by the Engineer, may be used instead of tamping irons.

Straightedges, ten feet in length, shall be provided to test the finished surface.

E. Inspection and Control of Asphalt Mixing Plant

3.26 GENERAL PROVISIONS.—For verification of weights and measures, character of materials and determination of temperatures used in the preparation of the

paving mixes, the Engineer or his authorized representative will at all times have access to all portions of the mixing plant, aggregate plant, storage yards and other facilities for producing and processing the materials of construction. All sampling and testing of processed and unprocessed material shall be under the control and direction of the Engineer, and shall be accomplished in accordance with the provisions set forth in Section B, "Materials and Tests."

3.27 JOB-MIX FORMULA.—The Engineer will make frequent gradation analyses of the hot aggregates and of the completed mix to be certain that the materials being used and produced are within the tolerances of the job-mix formula and the specifications of the mix number being used. If the mix is found to be outside of the job-mix formula tolerances, or outside of the specification limits (as shown in Section C), correction shall be made in quantities measured from the hot bins and adjustments made at the cold bin feeders.

3.28 SAMPLING AND TESTING.—Stockpiles and bins will be sampled for gradation analysis and examined for dust coating and for other purposes, in compliance with stated requirements.

Gradation analyses of each hot bin will be performed and a combined analysis computed at least twice a day —once in the forenoon, and once in the afternoon. A combined gradation analysis will be performed at least twice a day. If materials do not run uniform, more frequent tests will be made.

When requested by the Engineer, the Contractor shall provide representative samples by taking aggregate from the discharge of the aggregate through each of the hot bin gates, or by drawing aggregate from each bin through the mixing chamber (without asphalt) into a truck or other receptacle.

At least one sample shall be taken from each 300 tons of the mix being produced. Samples will be used to determine compliance with general and special requirements set forth in Section C, "Composition of Mixes."

F. Construction Methods

3.29 WEATHER LIMITATIONS.—When the moisture of the aggregate in the stockpile or from the dryer interferes with the quality of mix production, or with normal plant operations, or when pools of water are observed on the base, mixing and placing of hot-mix asphalt will not be permitted.

The temperature of the surface on which the hot-mix asphalt is placed shall be not less than 40°F. When the surface temperature on which the material is to be placed falls below 50°F., precautions shall be taken to compact the mix before it cools too much to obtain the required density.

All loads shall be delivered continuously in covered vehicles and immediately spread and compacted. In cold weather and for exceptionally long hauls, all trucks shall be insulated. All mixes shall be delivered at a temperature within 15°F. of that temperature specified by the Engineer.

3.30 PREPARATION OF AREA TO BE PAVED.—The area to be paved shall be true to line and grade, and have a dry and properly prepared surface prior to the start of paving operations. It shall be free from all loose screenings, and other loose or foreign material.

Where a base is rough or uneven, a leveling course shall be placed by use of a paver or motor grader and shall be properly compacted before the placing of subsequent courses.

When a leveling course is not required, all depressions and other irregularities shall be patched or corrected and the work approved by the Engineer before the paving operation begins. All fatty and unsuitable patches, excess crack or joint filler, and all surplus bituminous material shall be removed from the area to be paved. Blotting of excessive deposits of asphalt with sand or stone shall not be permitted.

Where the area to be paved is a prepared soil or aggregate base, it shall be primed in accordance with the provisions of Asphalt Institute Specification P-1, *As-*

phalt Priming of Granular Type Base Courses. The prime coat shall consist of an application of the asphaltic material indicated, and at the rate specified in Section A. The prime coat shall be allowed to cure properly before any further operations are permitted on the primed area.

A tack coat shall be applied when the surface to be paved is an existing portland cement concrete, brick or asphalt pavement. When a tack coat is required, it shall consist of an application of the asphaltic material indicated, and at the rate specified in Section A.

The surfaces of curbs, gutters, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin, complete coating of asphaltic material to provide a closely bonded, water-tight joint.

3.31 PREPARATION OF PAVING ASPHALT.—The asphalt shall be heated at the paving plant to a temperature at which it can be uniformly distributed throughout the mix. It shall be delivered into the Contractor's tank at a temperature not exceeding 350°F., and shall not be heated above this temperature for any operation of the paving plant.

3.32 PREPARATION AND HANDLING OF AGGREGATES.—Coarse and fine aggregates shall be stored at the plant in such a manner that the separate sizes will not become intermixed. Cold aggregates shall be carefully fed to the plant in such proportions that surpluses and shortages in the hot bins will not cause breaks in the continuous operation. When loading aggregate into stockpiles and into cars, barges, and trucks the material shall be placed in such a manner as to prevent segregation of aggregate sizes. Stockpiles shall be built in uniform layers not exceeding five feet in depth.

Coarse and fine aggregate shall be sampled and tested upon arrival at the plant in accordance with the standard methods specified in Article 3.09. Samples of coarse and fine aggregate shall be submitted to the En-

gineer for testing prior to the start of work, and as often thereafter as requested by the Engineer.

When coarse aggregate grading is such that the material will tend to segregate during stockpiling or handling, it shall be supplied in two or more sizes. Each size of coarse aggregate required to produce the combined gradation specified shall be placed in individual stockpiles at the plant site and separated by bulkheads or other means approved by the Engineer. Likewise, when it is necessary to blend fine aggregates from one or more sources to produce the combined gradation, each source or size of fine aggregate shall also be placed in individual stockpiles. Aggregate from the individual stockpiles shall be fed through separate bins to the cold elevator feeders. They shall not be blended in the stockpile.

(1) **Drying.** The aggregate shall be thoroughly dried and heated to provide a paving mix temperature within a tolerance ±15°F. of that specified by the Engineer. The moisture content of the heated and dried aggregate shall not exceed _____ percent.* The quantity of material fed through the dryer shall in all cases, be held to an amount which can be thoroughly dried and heated in accordance with that specified in "Proportioning and Mixing."

(2) **Screening.** Aggregates shall be screened into sizes such that they may be recombined into a gradation meeting the requirements of the job-mix formula.

(3) **Hot Aggregate Storage.** Hot screened aggregate storage shall be accomplished in such a manner as to minimize segregation and loss of temperature of the aggregate.

* **NOTE TO THE ENGINEER:** *The Engineer should specify here the maximum amount of moisture to be permitted. It is suggested that in most cases this should be 0.5 percent* or less.

3.33 PROPORTIONING AND MIXING.—To aid in determining the proper temperature of the completed batch, current viscosity data shall be provided and shall be available at the plant at all times. With information relative to the viscosity of the particular asphalt being used, the temperature of the completed mix at the plant and at the paver shall be designated by the Engineer after discussing with the Contractor the hauling and placing conditions.

The asphalt shall be heated so that it can be distributed uniformly throughout the batch. For mixing applications, the specified temperature generally (see Article 1.04) will be such that the asphalt viscosity is within the range of 150-300 centistokes (75-150 seconds, Saybolt Furol). The material shall be sufficiently fluid to produce a complete coating on every particle of aggregate within the specified mixing time. The temperature of the aggregates and asphalt immediately prior to mixing shall be approximately that of the completed batch.

When the mix is produced in a batch-type plant, the aggregate shall be weighed accurately in the designated proportions to provide the specified batch weight. The temperature of the aggregate at the time of introduction into the mixer shall be as directed by the Engineer, with a tolerance of ±15°F. In no case, however, shall the temperature of the mixture exceed 350°F.

Continuous mix plants shall, in general, be controlled in the same manner as batch-type plants. Details of control, differing because of the continuous mixing principle, shall be governed by instructions issued by the plant manufacturer, wherever these instructions are not contrary to these specifications.

3.34 CONTROL OF MIXING TIME.—The dry mixing period is the interval of time between the opening of the weigh box gate and the application of the asphalt. The wet mixing period is the interval of time between the application of all asphalt and the opening of the mixer gate for discharge. When it is applied by a spray system, the wet mixing time shall begin with the start of the asphalt spray.

(1) **Batch Type Plants.** * The Engineer will designate the length of time of both the dry and wet mixing periods to insure a uniformly and completely coated mix. Mixing period time shall not be altered unless so ordered by the Engineer. A dry mixing period of not less than five seconds shall precede the addition of the asphalt to the mix. Excess wet mixing shall be avoided. Wet mixing shall continue as long as is necessary to obtain a thoroughly blended mix but shall not exceed 75 seconds nor be less than 30 seconds.

(2) **Continuous Type Plants.*** The determination of mixing time shall be by a weight method under the following formula unless otherwise required:

$$\text{Mixing time, sec.} = \frac{\text{Pugmill Dead Capacity, lb.}}{\text{Pugmill Output, lb. per sec.}}$$

The weights shall be determined for the job from tests made by the Engineer.

3.35 TRANSPORTATION OF MIX.—The mix shall be transported to the job site in vehicles cleaned of all foreign material which may affect the mix. The truck beds shall be painted, or sprayed, with a lime-water, soap, or detergent solution, at least once a day or as often as required. After this operation the truck bed shall be elevated and thoroughly drained; no excess solution shall be permitted. The dispatching of the vehicles shall be so scheduled that all material delivered may be placed in daylight, unless the Engineer approves artificial light. Delivery of material to the paver shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

3.36 SPREADING AND FINISHING.—Spreading

* **NOTE TO THE ENGINEER:** *Mixing time requirements for both batch type and continuous type plants are currently under study by an AASHO-ARBA Cooperative Committee. Mixing time limitations may be changed when the committee completes its study.*

and finishing shall be conducted in the following manner:

(1) **Mechanical Pavers.** The base and surface courses shall be spread and struck-off with a mechanical paving machine meeting the requirements of Section D. The paving machine shall be operated so that material does not accumulate and remain along the sides of the receiving hopper.

Equipment which leaves tracks or indented areas which cannot be corrected in normal operation, or which produces flushing or other permanent blemishes or fails to produce a satisfactory surface, shall not be used.

Longitudinal joints and edges shall be constructed to true line markings. Lines for the paver to follow in placing individual lanes will be established by the Engineer parallel to the centerline of the proposed roadway. The paver shall be positioned and operated to follow closely the established line. When using pavers in echelon, the first paver shall follow the marks or lines, and the second paver shall follow the edge of the material placed by the first paver. In order to assure a hot joint and obtain proper compaction, the pavers shall work as close together as possible and in no case shall they be more than 100 feet apart.* In backing trucks against the paver, care shall be taken not to jar it out of its proper alignment.

As soon as the first load of material has been spread, the texture of the unrolled surface shall be checked to determine its uniformity. Segregation of

* **NOTE TO THE ENGINEER:** *When paving against a compacted mixture that has cooled, an infra-red type joint heater mounted on the side of the paving machine should help produce a hot and neat joint that, in most cases, will not be visible after compaction. When such joint heaters are used it usually is not necessary to trim or paint the edge of the previously laid lane. The temperature should be maintained between 235° and 285°F.*

materials shall not be permitted. If segregation occurs, the spreading operation shall be immediately suspended until the cause is determined and corrected.

Transverse joints in succeeding courses shall be offset at least two feet. Longitudinal joints shall be offset at least six inches.

Any irregularities in alignment left by the paver shall be corrected by trimming directly behind the machine. Immediately after trimming, the edges of the course shall be thoroughly compacted by tamping. Distortion of the pavement during this operation shall be avoided.

Edges against which additional pavement is to be placed shall be straight and approximately vertical. A lute or covered rake shall be used immediately behind the paver, when required, to obtain a true line and vertical edge. Any irregularities in the surface of the pavement course shall be corrected directly behind the paver. Excess material forming high spots shall be removed by a shovel or lute. Indented areas shall be filled with hot mix and smoothed with the back of a shovel being pulled over the surface. Fanning of material over such areas shall not be permitted.

(2) **Motor Grader.** When the Engineer permits the use of motor graders for the spreading of the mix, the material shall be placed on the roadbed in a windrow by a windrow-leveler, measuring device or by other methods appoved by the Engineer so that the proper amount of material is available. The mix shall be spread to the required thickness, line and grade with a uniform surface texture while at a workable temperature. The Engineer will specify the length of the windrowed mix ahead of the spreading operations, based upon the workability of the mix, weather conditions and the time required for the spreading operation.

(3) **Hand Spreading.** In small areas where the use of mechanical finishing equipment is not practical, the mix may be spread and finished by hand, if so

directed by the Engineer. Wood or steel forms, approved by the Engineer, rigidly supported to assure correct grade and cross-section, may be used. In such instances, measuring blocks and intermediate strips shall be used to aid in obtaining the required cross-section. Placing by hand shall be performed carefully; the material shall be distributed uniformly to avoid segregation of the coarse and fine aggregate. Broadcasting of material shall not be permitted. During the spreading operation, all material shall be thoroughly loosened and uniformly distributed by lutes or covered rakes. Material that has formed into lumps and does not break down readily shall be rejected. Following placing and before rolling, the surface shall be checked with templates and straightedges and all irregularities corrected.

Heating equipment used for keeping hand tools free from asphalt shall be provided. Caution shall be exercised to prevent high heating temperatures which may burn the material. The temperature of the tools when used shall not be greater than the temperature of the mix being placed. Heat only will be employed to clean hand tools; petroleum oils or solvents will not be permitted.

3.37 COMPACTION.—

(1) **General.** Rolling equipment for use in compacting mixes shall meet the requirements of Section D. Except for small jobs, such as driveways, at least two rollers shall be required at all times. As many additional rollers shall be used as necessary to provide specified pavement density.

During rolling, the roller wheels shall be kept moist with only sufficient water to avoid picking up the material.

After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides and gradually progress toward the center of the pavement. This holds true except on super-elevated curves where the rolling shall begin on the low side

and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each preceding track or covering the entire surface with the rear wheels when three-wheeled rollers are used. The rollers shall move at a slow but uniform speed with the drive roll or wheel nearest the paver. The speed shall not exceed three m.p.h. for steel wheeled rollers or five m.p.h. for pneumatic-tired rollers.

The line of rolling shall not be changed suddenly or the direction of rolling reversed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with lutes or shovels and restored to the original grade of the loose material before being rerolled. Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

When paving in single width, the first lane placed shall be rolled in the following order:

(a) *Transverse joints*
(b) *Outside edge*
(c) *Initial or breakdown rolling, beginning on the low side and progressing toward the high side*
(d) *Second rolling, same procedure as* (c)
(e) *Finish rolling* . .

When paving in echelon, or abutting a previously placed lane, the longitudinal joint rolling shall follow the transverse joint rolling.

When paving in echelon, two or three inches of the edge which the second paver is following shall be left unrolled, and rolled when the joint between the lanes is rolled. Edges shall not be exposed more than fifteen minutes without being rolled. Particular attention shall be given to the construction of transverse and longitudinal joints in all courses.

In laying a surface mix adjacent to any finished area it shall be placed sufficiently high so that, when compacted, the finished surface will be true and uni-

form. When the wearing course is placed adjacent to curbs to form an asphalt gutter, it shall be sealed with asphalt for a distance of 12 inches from the curb. The seal shall be evenly applied to the surface by means of hot irons or squeegees so that the surface voids are completely filled and no excess asphalt remains on the surface. When necessary to do this in areas carrying traffic, the Engineer may direct that the surface be lightly dusted. Where the grade is slight, gutters shall be checked with a straightedge and tested with running water to insure drainage to the desired outlet.

(2) **Transverse Joints.** Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be straightedged and stringlined to assure smoothness and true alignment. If the joint is formed with a bulkhead, such as a board, to provide a straight line and vertical face, it shall be checked with a straightedge before fresh material is placed against it to complete the joint. If a bulkhead is not used to form the joint and the roller is permitted to roll over the end of the new material, the line of joint shall be located back of the rounded edge a sufficient distance to provide a true surface and cross-section. If the joint has been distorted by traffic or by other means, it shall be trimmed to line. In either case, the joint face shall be painted with a thin coating of asphalt before the fresh material is placed against it.

To obtain thorough compaction of these joints, the material placed against the joint shall be tightly crowded against the vertical face of the joint. To accomplish this, the paving machine shall be positioned so that the material shall overlap the edge of the joint one inch to two inches. The depth of the overlapped material shall be kept uniform. The coarse aggregate in the overlapped material that has dislodged through raking or luting shall be removed from the pavement surface and discarded.

If a three-wheeled roller is used, it shall be placed

on the previously compacted material transversely so that not more than six inches of the rear rolling wheel rides on the edge of the joint. The roller shall be operated to pinch and press the mix into place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in six-to-eight-inch increments, until the joint has been rolled with the entire width of the roller wheel. Rolling shall be continued until a thoroughly compacted, neat joint is obtained. If only tandem rollers are available, they shall be similarly operated to complete the joint.

Tranverse joints shall be held to a minimum. When paving single width and maintaining traffic, one lane shall be taken no farther than one-half the total paving day. At the end of the paving day all lanes shall be completed to approximately the same station. When paving in echelon, the lanes shall be as nearly even as practical.

(3) **Longitudinal Joints.** Longitudinal joints shall be rolled directly behind the paving operation. The first lane placed shall be true to line and grade and have an approximately vertical face. The material being placed in the abutting lane shall then be tightly crowded against the face of the previously placed lane. The paver shall be positioned so that in spreading, the material overlaps the edge of the lane previously placed by one inch to two inches. The width and depth of the overlapped material shall be kept uniform at all times. The paver shall closely follow the line or markings placed along the joint for alignment purposes. Before rolling, the coarse aggregate in the material overlapping the joint shall be carefully removed with a rake or lute and discarded.

When rolling is accomplished with a three-wheeled roller, it shall be shifted over onto the previously placed lane so that not more than six inches of the rear roller wheel rides on the edges of the newly laid lane. The rollers shall then be operated to pinch and

press the fines gradually across the joint. Rolling shall be continued until a thoroughly compacted, neat joint is obtained. If only tandem rollers are available, they shall be similarly operated to complete the joint. When the abutting lane is not placed in the same day, or the joint is distorted during the day's work by traffic or by other means, the edge of the lane shall be carefully trimmed to line and painted with a very thin coating of asphalt before the abutting lane is placed.*

(4) **Edges.** The edges of the pavement shall be rolled concurrently with or immediately after rolling the longitudinal joint.

Care shall be exercised in consolidating the course along the entire length of the edges. Before it is compacted, the material along the unsupported edges shall be slightly elevated with a tamping tool or lute. This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat. In rolling pavement edges, roller wheels shall extend two inches to four inches beyond the pavement edge.

(5) **Breakdown Rolling.** Breakdown rolling shall immediately follow the rolling of the longitudinal joint and edges. Rollers shall be operated as close to the paver as necessary to obtain adequate density without causing undue displacement. The breakdown roller shall be operated with the drive roll or wheel nearest the finishing machine. Exceptions may be made by the Engineer when working on steep slopes or superelevated curves. When both three-wheeled rollers and tandem rollers are used, the three-wheeled rollers shall work directly behind the paver followed by the tandem rollers. Only experienced roller operators shall be used for this work.

* **NOTE TO THE ENGINEER:** *Refer to Note to the Engineer, Article 3.36(1).*

(6) **Second Rolling.** Pneumatic-tired rollers or tandem rollers, as described in Section D, shall be used for the second rolling. The second rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still of a temperature that will result in maximum density from this operation.

Pneumatic-tired rolling shall be continuous (at least three complete coverages) after the initial rolling until all of the mix placed has been thoroughly compacted. Turning of pneumatic-tired rollers on the hot paving mix which causes undue displacement shall not be permitted.

(7) **Finish Rolling.** The finish rolling shall be accomplished with two-axle tandems or three-axle tandems while the material is still warm enough for the removal of roller marks. If necessary to obtain the desired surface finish, the Engineer shall specify the use of pneumatic-tired rollers.

All rolling operations shall be conducted in close sequence.*

In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by trench rollers or others meeting the requirements of Section D. The trench roller shall be operated at the direction of the Engineer until the course is thoroughly compacted. Hand tamping, manual or mechanical, may be used in such areas if it is proved to the Engineer that such operations will give the desired density.

(8) **Shoulders.** Where paved shoulders are not used, the shoulder material shall not be placed against the edges of the pavement until the rolling of the surface course has been completed. Adequate precaution

* **NOTE TO THE ENGINEER:** *The following is a suggested guide: Longitudinal joint rolling directly behind the spreader; breakdown rolling less than 200 feet behind the spreader; second rolling 200 feet and more behind the breakdown rolling; finish rolling immediately behind the second rolling.*

shall be taken to prevent distortion of the pavement edge from specified line and grade. When shoulders are paved (except in conjunction with the traveled way paving) cold joint construction procedure shall be required to insure a tight bond at the joint.

When the rolling of the surface course has been completed and the edges have been thoroughly compacted, shoulder material shall be immediately placed against the edges and rolled.

3.38 DENSITY AND SURFACE REQUIREMENTS.—The completed pavement shall have a density equal to or greater than 97 percent of a laboratory specimen prepared as specified in Section C and made from plant mix conforming to the job-mix formula.

The final surface shall be of a uniform texture and shall conform to line and grade shown on the plans. Before final acceptance of the project, or during the progress of the work, the thickness of all courses will be determined by the Engineer. All unsatisfactory work shall be repaired, replaced or corrected.

Both density and thickness shall be carefully controlled during construction and shall be in full compliance with plans and specifications. During compaction, preliminary tests, as an aid for controlling the thickness, shall be made by inserting a flat blade, correctly graduated, through the material to the top of the previously placed base; or by other means approved by the Engineer.

In checking compacted depth, the cutting of the test holes, refilling with acceptable materials, and proper compaction shall be done by the Contractor under the supervision of the Engineer.

For the purpose of testing the surface on all courses a 10-foot straightedge shall be used.

The straightedge shall be held in successive positions parallel to the road centerline in contact with the surface, and the entire area checked from one side to the other. Advance along the pavement shall be in successive stages of not more than half the length of the straightedge.

Any irregularities which vary more than $^{3}/_{16}$ inch in 10 feet shall be corrected. Irregularities which may develop before the completion of rolling shall be remedied by loosening the surface mix and removing or adding material as may be required. Should any irregularities or defects remain after the final compaction, the surface course shall be removed promptly and sufficient new material laid to form a true and even surface. All minor surface projections, joints, and minor honeycombed surfaces shall be ironed smooth to grade, as may be directed by the Engineer.

G. Compensation

3.39 METHOD OF MEASUREMENT.—The bid items of "Asphalt Concrete (or Asphalt Plant-Mix) Surface Course," "Asphalt Concrete (or Asphalt Plant-Mix) Leveling Course" and "Asphalt Concrete (or Asphalt Plant-Mix) Base Course" shall be measured by the ton of 2,000 pounds of asphalt paving mixture, less the weight of the asphalt (determined in accordance with the following paragraph). The quantities measured for payment shall be the amount of asphalt paving materials actually used in the completed and accepted work in accordance with the plans and specifications. Measurement of asphalt paving mixtures, unless otherwise provided, shall be by weight on truck scales meeting the requirements of Section D.

The unit of measurement for "Asphalt in Paving Mixture," "Asphalt for Tack Coat," and "Asphalt for Prime Coat" shall be the ton of 2,000 pounds, or gallon, whichever is called for in the bid schedule. The tonnage or gallonage to be paid for shall be the number of tons or gallons of these asphaltic materials used as ordered in the accepted work. Tonnage used in the paving mixture may be computed from the truck weigh tickets by using the percentage of asphalt in the approved mix. Tonnage or gallonage used for tack and prime coat may be computed from quantity measurements in the distributor tank before and after application. At the option of the

Engineer the items of asphaltic materials may be measured on the basis of certified delivery receipts. Gallonage shall be determined by converting the gallonage measured at other temperatures to gallonage at 60°F. in accordance with ASTM Designation D 1250 for each respective type and grade required.

3.40 BASIS OF PAYMENT.—The quantities of "Asphalt Concrete (or Asphalt Plant-Mix) Surface Course," "Asphalt Concrete (or Asphalt Plant-Mix) Leveling Course," and "Asphalt Concrete (or Asphalt Plant-Mix) Base Course" measured as specified in "Method of Measurement," shall be paid for at the unit price per ton of 2,000 pounds, which prices and payments shall constitute full compensation for cleaning base of underlying course; for producing, furnishing, transporting, stockpiling, heating, drying and screening of aggregate materials; for furnishing, handling, measuring, mixing, manipulating and placing of materials; for hauling, placing, shaping, compacting and finishing of the paving mix; for improving unsatisfactory areas; for reconditioning underlying courses; for furnishing samples; for furnishing, testing and sealing of scales; for furnishing the weigh house and field laboratory; for maintenance of the completed work until final acceptance; for all materials (exclusive of asphalt), manipulation, labor, tools, equipment and incidentals necessary to complete the work in full compliance with the plans and specifications.

The quantities of "Asphalt in Paving Mixture," "Asphalt for Tack Coat," and "Asphalt for Prime Coat" of each type and grade used, measured as provided in "Method of Measurement," will be paid for at the unit prices bid per ton (or gallon), which price shall be full compensation for furnishing, handling, storing, heating, transporting and placing in the mixture, or applying to the work; for all samples; and for all labor, tools, equipment and incidentals necessary to complete the work in full compliance with the plans and specifications.

Payment will be made under:

Item No. ___ Asphalt Concrete (or Asphalt Plant-Mix)*
Surface Course—per ton

Item No. ___ Asphalt Concrete (or Asphalt Plant-Mix)*
Base Course—per ton

Item No. ___ Asphalt Concrete (or Asphalt Plant-Mix)*
Leveling Course—per ton

Item No. ___ Asphalt in Paving Mixture—per ton (or per gallon) *

Item No. ___ Asphalt for Tack Coat—per ton (or per gallon) *

Item No. ___ Asphalt for Prime Coat—per ton (or per gallon) *

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* **NOTE TO THE ENGINEER:** *The Engineer should delete either "Asphalt Concrete" or "Asphalt Plant-Mix" as appropriate. He also should delete either "per ton" or "per gallon" in showing which unit of measurement he desires as a basis of payment for asphalt. He should insert his Item Numbers to fit his project bid schedule.*

APPENDICES

APPENDIX A

Plant-Mix Pavements Using Liquid Asphalts

A. Introduction

A.01 PURPOSE AND SCOPE.—The purpose of this appendix is to provide engineers with information on construction methods for plant-mix pavements using liquid asphalts: (Medium Curing and Slow Curing Liquid Asphalts and Emulsified Asphalts). It includes information on (1) plant-mix, cold-laid paving mixtures using liquid asphalts; (2) plant-mix, hot-laid paving mixtures using liquid asphalts; and (3) plant-mix, cold-laid paving mixtures using paving grade asphalt cements with a liquefier. The use of Rapid Curing Liquid Asphalts in plant mixing is not recommended because of the danger involved.

Those paving mixtures which are termed *cold-laid* are usually at or near atmospheric (ambient) temperature when they are being placed and compacted. They remain workable for long periods, hence in addition to being suitable for immediate use, they may be transported for long distances and may be placed in stockpiles for future use in patching and other maintenance work.

From the procedures outlined herein, the engineer will be able to prepare specifications to meet most requirements. Selection of other mix compositions or modifications of those outlined are justified when supported by practices which have been proven successful in local use.

A.02 GENERAL PROCEDURES.—Procedures and terminology for plant-mixes with liquid asphalts are similar to those specified for hot-mix asphalt concrete. As will be described they are less exacting in many respects, such as the lower temperature requirements for mixing and placing, the lesser requirement for drying of aggregates, and in the fewer tests and control procedures that are used. Consequently, they are easier and more economical to produce.

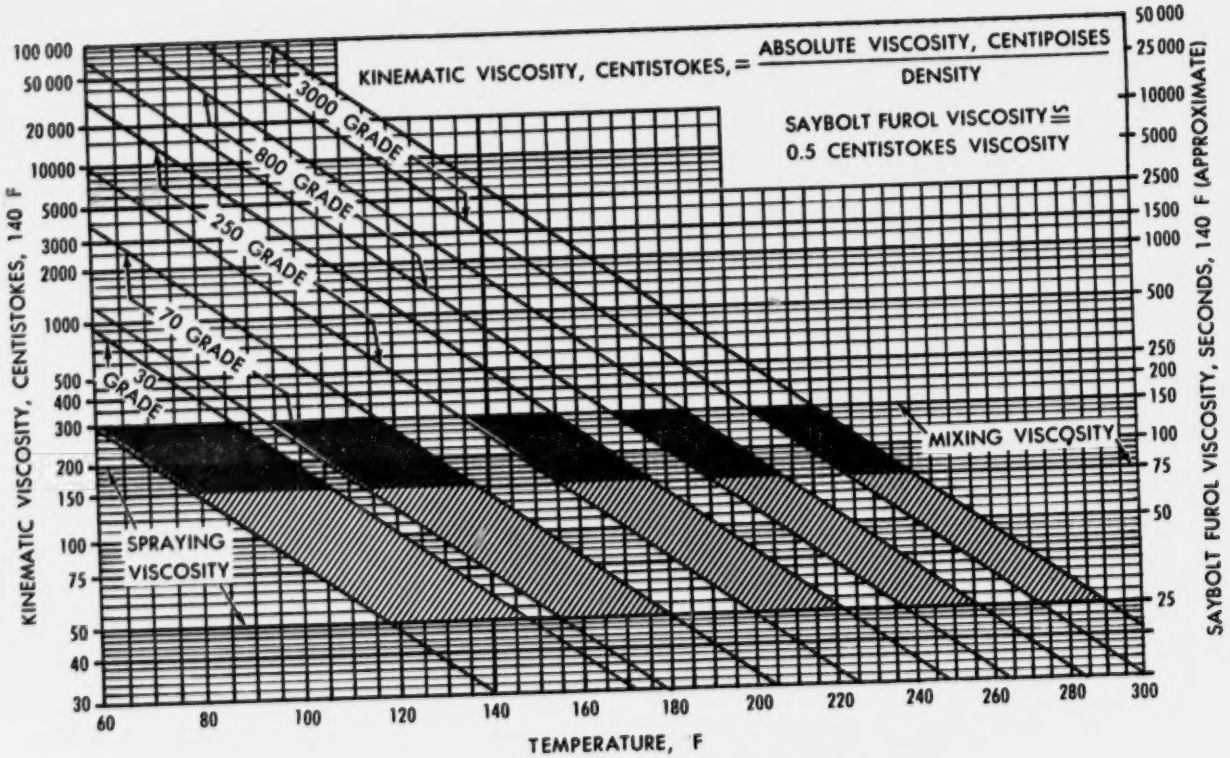


Figure A-1—Temperature-Viscosity of Liquid Asphalts

Regardless of the mix type, however, the asphalt used must be sufficiently fluid to insure adequate coating of the mineral aggregate during mixing operations and workability of the resultant mix until it is placed and compacted. This requirement usually insures that it is also sufficiently fluid to be handled by the pumping system of the mix plant. The measure of this fluidity is termed viscosity. To obtain the needed viscosity for proper mixing and workability of hot-mix, both the asphalt cement and the aggregate must be at relatively high temperatures during mixing and placing. Liquid asphalts, being already fluid, need only a small supplement of heat to obtain the viscosity necessary for proper mixing and workability. Viscosity-Temperature relationships of the RC, MC and SC liquid asphalts are depicted in Figure A-1. From this graph the application temperatures of these liquid asphalts can be readily determined.

Aggregates for these mixes are not required to be as closely controlled in temperature and dryness as they are for hot-mixes. When an MC or SC liquid asphalt is used as the binder, the aggregate is usually introduced into the mixer at temperatures near ambient, but they must be surface dry. The presence of some moisture in the aggregates actually facilitates mixing procedures but too much moisture may hinder compaction of the mix after it is placed. Those mixes (Table A-2) that utilize MC and SC-3000 require that the aggregate be at approximately the same temperature as the asphalt. The above requirements may make it necessary to process the aggregates through a dryer. A dryer is not needed when an asphalt emulsion is to be the binder as aggregate of higher moisture content can be tolerated with these mixes.

A.03 MIX DESIGN PROCEDURES.—The only well known mix design procedure applicable to paving mixtures using liquid asphalts is the Hveem Method, developed and used by the California Division of Highways (described in ASTM Test Methods D 1560 and D 1561).

The first step in the Hveem Method is the determination of the "estimated optimum" asphalt content by the Centrifuge Kerosene Equivalent (CKE) Method (described in Chapter V, *Mix Design Methods For Asphalt Concrete,* Manual Series No. 2, [MS-2], The Asphalt Institute).

Though the methods above for mix design and estimation of liquid asphalt content are preferred, it is recognized that the necessary laboratory equipment may not be available. For this reason the tables herein (Tables A-1, A-2, and A-3) give ranges of liquid asphalt contents that encompass all types of aggregates and conditions of use and which may be used as guides.

Estimates of liquid asphalt content, either by the CKE Method or by selection from the tables, are to be used only in Design or Preliminary Job-Mix Formulas. The Final Job-Mix Formula is determined after the asphalt plant is in regular operation and the characteristics of the production mix have been established on the job.

A.04 MIXING AND PAVING PROCEDURES.—The mixes described in this Appendix are combined in standard asphalt mix plants. The plant used must be capable of producing the paving mixture desired and may vary from a simple layout to the most complex. Procedures for plant operation are described in the *Asphalt Plant Manual* Manual Series No. 3, (MS-3) The Asphalt Institute.

Finished mixtures should be placed in accordance with procedures described in the *Asphalt Paving Manual* Manual Series No. 8 (MS-8), The Asphalt Institute. After the mixture is placed, it should be compacted with suitable equipment such as will provide adequate densification of the finished pavement course or patch.

A.05 SPECIAL TEST PROCEDURES.—Proper densification of completed pavements made from these mixes is equally important to that for pavements made from hot-mix. This density should be equal to or greater than 95 percent of that of a laboratory specimen prepared by a 50-blow Marshall compactive effort or its

equivalent. The laboratory test specimens of paving mixes should be prepared from uncompacted mix material taken from the pavement at the time of placing and immediately prior to field compaction. It must be insured that the laboratory specimens are prepared from the material before changes take place (such as further loss of volatiles) that limit its comparability to the field specimens. The volumetric method for density determination should be used to determine the density of both the laboratory specimens and the field pavement specimens.

Mixes which require reduction of volatiles and/or water before compaction should be aerated by continued manipulation with blades, or other suitable devices, which do not segregate the mix. Proper aeration is reached when volatile content has been reduced to 50 percent of that contained in the original asphalt and the moisture content does not exceed two percent by weight of the total mix (two to five percent for emulsion mixes). (These values to be determined in accordance with AASHO Method of Test T 110).

B. Composition of Plant-Mix Paving Mixtures Using Liquid Asphalts

A.06 PLANT-MIX, COLD-LAID PAVING MIXTURES USING LIQUID ASPHALTS.—Finished mixtures of this type may be placed immediately on the roadway, may be transported for considerable distances before being placed or may be stored in stockpiles for future use. The proposed use will influence the type and grade of liquid asphalt that should be selected.

When these mixtures are stockpiled for later use, the stockpiles should be placed in well drained, accessible locations and should be carefully shaped to shed rain water and thus prevent saturation of the mix.

In placing these mixtures they should be manipulated and spread with equipment, usually a motor grader, in a manner that will provide for thorough aeration before

they are compacted in place. As an alternate they may be shovelled into place and raked to a loose uniform layer of correct depth.

Difficulty is sometimes encountered in this type of mix in coating the aggregate with asphalt. When this happens the addition of one-half to one percent of hydrated lime, near the end of the wet mix cycle, should be beneficial.

A compilation of recommendations for mixture of this type is given in Table A-1.

A.07 PLANT-MIX, HOT-LAID PAVING MIXTURES USING LIQUID ASPHALTS.—Paving mixes that are made with the highest viscosity liquid asphalt binders (MC and SC-3000) should be mixed, placed and compacted at elevated temperatures. In this respect they are similar to regular hot-mix (using asphalt ce-

TABLE A-1—SUGGESTED COMPOSITION OF PLANT-MIX, COLD-LAID PAVING MIXTURES USING LIQUID ASPHALTS

MIX NO.	IV a	IV b	IV c
USE	Surface Patch	Surface, Patch	Base, Surface, Patch
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	¾ in.- 2 in.	1 in.- 3 in.	1½ in.- 4 in.
SIEVE SIZE	Percent Passing By Weight		
1 in.			100
¾ in.		100	80-100
½ in.	100	80-100	
⅜ in.	80-100	70-90	60-80
No. 4	55-75	50-70	48-65
No. 8	35-50	35-50	35-50
No. 30	18-29	18-29	19-30
No. 50	13-23	13-23	13-23
No. 100	8-16	8-16	7-15
No. 200	4-10	4-10	0- 8

Normal liquid (actual, not residual) asphalt content 4.0 - 10.0 percent by weight of total mix. Upper limits may be raised when using highly absorptive aggregates.

TABLE A–1 (continued)

LIQUID ASPHALT SELECTION:
FOR BASE AND SURFACE COURSES

GRADE	TEMPERATURE * DEGREES F.	REMARKS
MC-800	170-205	For general use under average weather conditions.
SC-800	170-205	For mixing and placing under hot, dry weather conditions.
SS-1	75-130	For use when selection of an emulsion is indicated.
SS-K & SS-Kh	75-130	When conditions indicate use of an emulsion; particularly advantageous for hydrophyllic aggregates.
For Patching (immediate use or stockpile)		
MC-250	135-175	For immediate use under hot or moderate weather conditions or for stockpile.
SC-250	135-175	For mixes that are stockpiled for extended periods.
SC-800	170-205	For immediate use under moderate weather conditions.

AGGREGATE

Sound, angular crushed stone, crushed gravel or crushed slag and fine aggregate should be introduced into the mix at, or near, ambient temperature, but temperatures below 50°F. or above temperature of liquid asphalt should not be permitted.

ment binders). From Figure A-1 it may be seen that mixing temperatures required for these asphalt binders are in the range 200-240°F. Aggregates should be delivered to the mixer within these same temperature limits. The key to proper placing and compacting is workability of the mix. This will require that these mixes be placed and compacted while they are still at or near the specified mixing temperatures (in some instances this is specified as not more than 20°F. below mixing temperature). The length of time available for these operations depends on the weather and, in general, these mixtures should not be placed when the air temperature is below 45°F.

* *Temperature at which liquid asphalt should be introduced into the mix.*

Usually the mixing temperatures required will result in the dissipation of most of the volatiles of the liquid asphalt binders. In the cases where this is not so (where the mix displaces too much during compaction) these mixtures may have to be aerated before they are compacted. They may be spread by means of a paving machine, or by use of a motor grader from a windrow. Generally if the compacted thickness of a paving course exceeds two inches, the mixture should be spread in two or more layers. The actual key to maximum course thickness permitted is the ability of the compaction equipment available to attain the specified density. If deposited in a windrow the mixture should be bladed out by motor grader in a succession of layers of approximately one inch thickness to a uniform cross section so as to produce the compacted thickness specified.

Table A-2 is a compilation of recommendations for mixtures of this type.

A.08 PLANT-MIX, COLD-LAID, PAVING MIXTURES USING A PAVING GRADE ASPHALT CEMENT WITH A LIQUEFIER.—Instances arise when a cold-laid plant mix is needed and it is not economical to obtain, transport or store liquid asphalt binders for this use. It is possible to design this type of mix utilizing a regular paving grade asphalt cement with a liquefier and hydrated lime.

After these mixtures are produced the procedures for placing them are similar to those for plant-mix, cold-laid mixtures using liquid asphalt binders. They may be placed at or near ambient temperatures. They may be transported for considerable distances, and they may be stockpiled for future use.

Table A-3 contains recommendations for paving mixtures of this type.

TABLE A–2—SUGGESTED COMPOSITION AND USE OF PLANT-MIX HOT-LAID PAVING MIXTURES USING LIQUID ASPHALT

MIX NO.	IV a	IV b
USE	Surface	Surface
COMPACTED DEPTH RECOMMENDED FOR INDIVIDUAL COURSES	1 in. Feather Edging	1 in. 2 in.
SIEVE SIZES	Percent Passing By Weight	
¾ in.		100
½ in.	100	80-100
⅜ in.	80-100	70-90
No. 4	55-75	50-70
No. 8	35-50	35-50
No. 30	18-29	18-29
No. 50	13-23	13-23
No. 100	8-16	8-16
No. 200	4-10	4-10

NOTES

Normal asphalt content 4.0 - 8.0 percent by weight of total mix. Upper limit may be raised when using highly absorptive aggregates.

An MC-3000 grade liquid asphalt should be selected for mixing and placing under average conditions. For hot, dry weather conditions the SC-3000 grade should be selected.

Aggregate required: Sound, angular crushed stone, crushed gravel, or crushed slag, and fine aggregate.

Mixing Temperature: 200-240°F. for liquid asphalt and aggregate.

TABLE A-3—SUGGESTED COMPOSITION OF PLANT-MIX, COLD-LAID PAVING MIXTURES USING PAVING GRADE ASPHALT CEMENT WITH A LIQUEFIER

Mineral Aggregate
(Hard, Sound, Angular Crushed Stone, Crushed Gravel, or Crushed Slag and Fine Aggregate)

USE	Base Course	Surface Course
SIEVE SIZE	Percent Passing	Percent Passing
1½ in.	100	
1 in.	90-100	
¾ in.	40-75	
½ in.	10-35	100
⅜ in.	5-25	90-100
No. 4	0-20	20-40
No. 8	0-10	15-30
No. 16		10-25
No. 30		5-15
No. 50		0-10
No. 200		0- 5

Mixing Temperature: Ambient; however temperature below 50°F. or above 150°F. should not be permitted.

Asphalt Cement: ..... 85—100 grade
Mixing Temperature: ..... 275—325°F.

Liquefier: Petroleum distillate of the kerosene or stove oil type which meets the following requirements:

Flash Point, Open Cup	115°F. Minimum
Initial Boiling Point	300°F. Minimum
Final Boiling Point	635°F. Maximum

(Some authorities specify a petroleum naphtha, AASHO Designation M 83, as the liquefier)

Hydrated Lime: Conforming to requirements of ASTM C-6

TABLE A-3 (Continued)

Proportioning	Percent by Weight of Total Mix	
	Base Course	Surface Course
Asphalt Cement	3.5—5.0	4.5—6.0
Liquefier	0.5—1.5	0.5—2.0
Hydrated Lime	0.5—1.0	0.5—1.0

NOTES

(1) During hot weather, a workable mix can be obtained with less liquefier and more mineral dust than in cold weather.

(2) One sequence of introducing materials into the mixer is aggregate, liquefier, asphalt cement and hydrated lime. After the aggregate has been mixed dry, it should be sprayed with the liquefier and mixing continued until the aggregate is coated. Asphalt cement and hydrated lime should then be introduced successively, and mixing continued until a uniformly coated mixture is obtained. Minimum mixing times should be 15 seconds of dry mixing, 15 seconds after addition of liquefier, and one minute after adding the asphalt cement and hydrated lime. In all, mixing should be continued until a uniform, homogeneous and workable mixture is obtained.

A variation of the above sequence can be used when it is desired to increase the workability of the mix, as for extended storage in stockpile. This is to introduce about one-half of the liquefier initially and the remainder toward the end of the wet mix cycle.

(3) Aggregates for these mixtures are specified as being surface dry (as for cold-laid mixtures with liquid asphalt binders). However, some authorities specify that the moisture content must be less than four-tenths of one percent.

(4) The above table and notes are intended as guides. There are other mix compositions and procedures with service histories of successful use. Where such are available in local situations it is good practice to be guided by them.

APPENDIX B

Proposal and Preliminary Engineering Report
for
The Construction of Asphalt Paving

From _____ to _____

County of _____

State of _____

PAVING AUTHORITY

_____ Official

_____ Official

_____ Official

_____ Official

_____ Official

Date _____

A. PROJECT DESCRIPTION

(1) *Location:* This paving project _____ miles

in length, starting _____

and ending _____

(Indicate the actual length of the paving project along with a brief description of its terminal points.)

(2) *Terrain:* The area traversed by this project is

_____

_____

(Indicate whether rural or urban, population density, wooded or farmland, rolling or flat topography.)

(3) *Climate:* The climate in the area of the project is

_____

_____

(Describe seasonal characteristics indicating temperature ranges, humidity, rainfall, snowfall, frost depth, etc. Use such phrases and words as "arid," "semi-arid," "cool-moist," "fog-bound," "cold winters and dry summers," etc., where applicable.)

B. PAVEMENT STRUCTURE DESIGN (Refer to *Thickness Design—Asphalt Pavement Structures for Highways and Streets,* Manual Series No. 1 (MS-1), The Asphalt Institute. Within a project more than one pavement structure design may be necessary if conditions vary markedly.)

(1) *Traffic Analysis:*

(a) Highway Classification _____
(City street, local rural road, interurban highway, or urban highway)
Initial Daily Traffic _____ vehicles
(Estimated volume in two directions. For use with the simplified Traffic Analysis Chart in Chapter II, MS-1.)

(b) Loadometer and Truck Weight Survey: (For use with detailed method in Appendix A, MS-1. A survey of similar facilities may be used, or data may be taken from Tables W-1, W-2, or W-4 of the state highway departments annual report to the Bureau of Public Roads, titled "Loadometer and Truck Weight Studies.")

(c) Design Period (as for Planned Stage Construction, or when otherwise different from base 20-year design) _____ years.

(d) Design Traffic Number _____
(From the simplified chart in Chapter II, or the detailed method of Appendix A, MS-1.)

(2) *Subgrade Evaluation:*

Soil Classification _____
(AASHO or Unified Soil Classification)
Design Strength Value of Subgrade _____
(CBR, R-Value, or Plate Bearing Value from measured strength tests. For design of Light Traffic Pavements procedures based on soil classifications alone may be used to estimate the CBR.

(3) *Thickness Design Recommended:*

(From Charts and Methods of Chapter IV, MS-1.)
Asphalt Concrete (or Asphalt Plant-Mix) Surface _____ inches

Asphalt Concrete (or Asphalt Plant-Mix) Leveling _____ inches

Asphalt Concrete (or Asphalt Plant-Mix) Base _____ inches

Asphalt Treated Base _____ inches

Granular Base _____ inches

Subbase _____ inches

Improved Subgrade _____ inches

Total _____ inches

(Disregard any of above courses not used)

(4) *Cross-Section Design Recommended:*

_____

_____

_____

_____

(Describe the pavement width, number of traffic lanes, base width and shoulder width and, for divided highways, the type and width of median.)

C. PAVING MIXES: The asphalt paving mixes recommended for this project are The Asphalt Institute's Mix Type ____ for Surface Course; Mix Type ____ for Leveling Course; Mix Type _____ for

Base Course. These paving mixes are recommended because

_____

_____

_____

_____

(The selection of paving mix types should, in general, be in keeping with that which has been proven satisfactory with local materials and practice for comparable pavement design and traffic conditions. This may require a survey of local practice. The engineer should call on federal, state, county, and city engineering agencies to ascertain the mix gradations they are using for comparable work. If the project concerns residential streets, the engineer should inquire into local practice for that particular type of work; if for highways or farm-to-market roads, inquiries should be directed along those lines. He should also inquire about pavement performance records and note special topographical and climatic conditions. He should also note if there has been a change in the aggregate supply. He should use mix gradations found to be satisfactory for projects most similar to his own project and compare them to The Asphalt Institute mixes. If practical, he should make a tentative selection of two or three mixes [later to be reduced to one] and make a personal tour of local jobs to inspect surface texture and other observable good and bad qualities. The recommendations for paving mixes should be supported by a brief narration comparing the mixes with local paving practice

and locally available aggregates. He should cite also the characteristics of recommended paving mixes which make them especially suitable.)

D. AGGREGATE MATERIALS: Aggregates of suitable quality, quantity, and gradation for the production of plant-mix asphalt paving are available locally from the following sources:

Coarse Aggregates _____

_____

_____

Fine Aggregates _____

_____

Mineral Filler _____

_____

(The engineer should list both local commercial sources of aggregates and local natural aggregate deposits [as the case may apply] for coarse and fine aggregates and mineral filler. In the case of natural aggregate deposits, findings should be factual, based on adequate prospecting, sampling, and testing, and comprehensive as to size and importance of the project. He should make certain that the local aggregate sources listed are economical and will produce gradations suitable for the job requirements. This survey of aggregates is important and the engineer should spare no effort to see that it is properly conducted, particularly if the local aggregate supply is uncer-

tain or unknown. If the engineer does not have time and/or equipment to do the work himself, he should employ an engineer or an engineering firm to do the work for him. The prospecting, sampling, and testing must be done by qualified persons; where there is no locally organized aggregate industry the prospecting should be especially thorough.)

E. ASPHALT: Based on local practice, prevailing climate, and pavement requirements, asphalt grade of _____ is recommended.

(Insert the penetration grade or the type and grade of liquid asphalt selected. Again the engineer should refer to local practice in the use of asphalts. Penetration grades recommended by The Asphalt Institute for various conditions are shown in Table II-2, liquid asphalts in Appendix A.)

F. CONTRACTORS AND CONSTRUCTION METHODS: Equipment and labor for the construction of the proposed paving project are locally available through the established contractors in this area. In addition, the specifications for the proposed work conform with local practice insofar as it is consistent with a high quality product.

(The engineer should make certain that the above statements are compatible with the paving mix recommended. See Tables II-4 through II-11 and A-1 through A-3 for description and usage of paving mixes. Size of plant required for the job to be done should be specified, as well as the number of hot bins required, keeping in mind the local availability of various sizes of plants. Specifications should not be unnecessarily strict making conformance impractical or uneconomical.)

G. SUMMARY OF SELECTION FACTORS: The

foregoing features of the proposed paving project have been selected and recommended because _____

_____

_____

(Here there should be briefly summarized the basis for the selection of the basic features of the proposed construction, particularly the relation between the selection of paving mix type, locally available aggregates, and the design requirements of paving. It should be shown that the final choice is the best economically, consistent with the desired quality.)

H. COST ANALYSIS: The following is a cost analysis of the proposed paving project based on the calculated quantities and estimated unit price.

ITEM	UNITS—SQUARE YARDS, TONS OR GALLONS	QUANTITIES	ESTIMATED UNIT PRICES
Asphalt Concrete (or Asphalt Plant-Mix) Surface			
Asphalt Concrete (or Asphalt Plant-Mix) Leveling			
Asphalt Concrete (or Asphalt Plant-Mix) Base			
Asphalt-Treated Base			
Granular Base			
Subbase			
Improved Subgrade			
Asphalt (Prime, Tack or Mixing)			

Estimated Cost per Square Yard $_____

(This information may be obtained by actual detailed estimates and published materials prices or from published bid prices for comparable work in a comparable location.)

APPENDIX C

TABLE C–1 POSSIBLE CAUSES OF IMPERFECTIONS IN FINISHED PAVEMENTS

Insufficient or Non-Uniform Tack Coat	Improperly Cured Prime or Tack Coat	Mixture Too Coarse	Excess Fines in Mixture	Insufficient Asphalt	Excess Asphalt	Improperly Proportioned Mixture	Unsatisfactory Batches in Load	Excess Moisture in Mixture	Mixture Too Hot or Burned	Mixture Too Cold	Poor Spreader Operation	Spreader in Poor Condition	Inadequate Rolling	Rolling at Wrong Time	Over-Rolling	Rolling Mixture When Too Hot	Rolling Mixture When Too Cold	Roller Standing on Hot Pavement	Overweight Rollers	Roller Vibration	Unstable Base Course	Excessive Moisture in Subsoil	Excessive Prime Coat or Tack Coat	Poor Handwork Behind Spreader	Excessive Hand Raking	Labor Careless or Unskilled	Excessive Segregation in Laying	Faulty Allowance for Compaction	Operating Finishing Machine Too Fast	Mix Laid in Too Thick Course	Traffic Put On Mix While Too Hot	Types of Pavement Imperfections That May Be Encountered In Laying Plant Mix Paving Mixtures.
					X			X	X														X								Bleeding
				X		X	X																X								Brown, Dead Appearance
		X	X			X	X			X	X	X	X	X		X	X							X		X					Rich or Fat Spots
X	X	X				X	X			X	X	X	X	X		X	X	X	X	X				X	X	X		X				Poor Surface Texture
		X		X		X	X			X	X	X	X	X			X							X	X	X						Rough Uneven Surface
		X								X	X	X	X	X										X	X	X						Honeycomb or Raveling
		X								X	X	X	X	X		X	X							X	X	X	X					Uneven Joints
			X		X	X				X			X	X												X						Roller Marks
X	X		X		X	X	X	X				X	X	X		X			X	X	X								X	X		Pushing or Waves
			X	X		X								X	X	X			X		X	X										Cracking (Many Fine Cracks)
															X				X		X	X										Cracking (Large Long Cracks)
		X				X				X	X	X		X	X	X			X		X						X					Rocks Broken by Roller
		X		X		X			X	X	X	X																X				Tearing of Surface During Laying
X	X		X		X	X		X		X			X	X	X		X		X		X	X	X									Surface Slipping on Base

TABLE C–2 POSSIBLE CAUSES OF DEFICIENCIES IN PLANT-MIX PAVING MIXTURES

Types of Deficiencies That May Be Encountered in Producing Plant-Mix Paving Mixtures.	Aggregates Too Wet	Inadequate Bunker Separation	Aggregate Feed Gates Not Properly Set	Over-Rated Dryer Capacity	Dryer Set Too Steep	Improper Dryer Operation	Temp. Indicator Out of Adjustment	Aggregate Temperature Too High	Worn Out Screens	Faulty Screen Operation	Bin Overflows Not Functioning	Leaky Bins	Segregation of Aggregates in Bins	Carryover in Bins Due to Overloading Screens	Aggregate Scales Out of Adjustment	Improper Weighing	Feed of Mineral Filler Not Uniform	Insufficient Aggregates in Hot Bins	Improper Weighing Sequence	Insufficient Asphalt	Too Much Asphalt	Faulty Distribution of Asphalt to Aggregates	Asphalt Scales Out of Adjustment	Asphalt Meter Out of Adjustment	Undersize or Oversize Batch	Mixing Time Not Proper	Improperly Set or Worn Paddles	Faulty Dump Gate	Asphalt and Aggregate Feed Not Synchronized	Occasional Dust Shakedown in Bins	Irregular Plant Operation	Faulty Sampling
Asphalt Content Does Not Check Job Mix Formula			A													B				A	A				C	B	B	A	C	A		A
Aggregate Gradation Does Not Check Job Mix Formula			A													B	B	A			A					B	B		C	A		A
Excessive Fines in Mix			A													B	B	A			A											
Uniform Temperatures Difficult to Maintain																																
Truck Weights Do Not Check Batch Weights		A										B																				
Free Asphalt on Mix in Truck												B									A	B	C		B							
Free Dust on Mix in Truck												B													C							
Large Aggregates Uncoated																B			A									B				
Mixture in Truck Not Uniform		A		A	A	A													A	B	C	B	A	B	C	B	A	B	C	A	A	
Mixture in Truck Fat on One Side				A	A	A	A					A	A	A	A	B	B	A	A	B	C	B	A	B	C	B	A	B	C	A	A	
Mixture Flattens in Truck																															A	
Mixture Burned						A													A	B	C	B									A	
Mixture Too Brown or Gray		A		A	A	A				A																			C		A	
Mixture Too Fat			A		A	A					A								A	B	C	B							C		A	
Mixture Smokes in Truck				A		A									B	B	A	A		A	B	C	B								A	
Mixture Steams in Truck		A		A	A	A																									A	
Mixture Appears Dull in Truck			A		A	A						A																		A	A	

A—Applies to Batch and Continuous Type Plants. B—Applies to Batch Plants only. C—Applies to Continuous Plants only.

APPENDIX D

Sampling Asphalt Products and Specification Compliance

NOTE

Material to Supplement "Sampling Bituminous Materials," AASHO Designation T 40 (ASTM Designation D 140)

D.01 NECESSITY FOR STRICT CONTROL PROCEDURES.—The contributing causes for off-specification material can be quite numerous, but it appears from test results that contamination of the material is the prime culprit. Results point out that the majority of off-specification samples have had flash points too low, penetrations too high, viscosities too low, or erratic results of the distillation tests. All of these are inherent with solvent type contamination.

Various laboratories have conducted experiments which indicate that one-tenth of one percent of diesel oil in asphalt cements may lower the flash point by as much as 50°F. (Pensky-Martens Flash Point Test), and may increase the penetration by as much as 10 points. In many cases this change is sufficient to cause material to be out of specification. This one-tenth of one percent amounts to 5 gallons of contaminant in 5,000 gallons of asphalt, or 0.03 ounces in a quart sample.

To insure quality work, then, it is extremely important that contamination of asphalt products be prevented, from the time they leave the refinery to their incorporation in completed work. This importance also extends to the matter of samples and sampling procedures. Tests carried out to insure compliance with specifications are only valuable when they are performed on

samples which are truly representative of the material under consideration.

Most agencies or users require that the supplier furnish written certification that asphaltic material meets the specifications at the time of loading into the hauling vehicle. Test results of samples taken at the refinery or suppliers storage facility indicate that in virtually all cases, the asphalt has complied with specifications.

Actually in many cases job samples are being taken at points as close as possible to the completed work, such as: (1) from the distributor tank or its spray nozzles in spraying operations; and (2) from the pumping lines between the storage tank and the plant in plant-mix operations.

The following sections list some of the causes of contamination and some suggested precautions to help prevent it.

D.02 POSSIBLE CAUSES OF CONTAMINATION OF ASPHALTIC MATERIAL OR SAMPLES AND SUGGESTED PRECAUTIONS.—

(1) **Haulers and Hauling Vehicles.** Field observations and studies of test results have indicated that contamination of materials during transportation has occurred quite frequently and regularly.

POSSIBLE CAUSES	PRECAUTIONS
(a) Previous load not compatible with material being loaded.	Examine the log of loads hauled or check with the supplier to determine if previous material hauled is detrimental. If it is, make sure vehicle tanks, unloading lines, and pump are properly cleaned and drained before being presented for loading. Provide a ramp at the unloading point at the plant that will assure complete drainage of vehicle tank while material is still fluid.

(b)	Remains of diesel oil or solvents used for cleaning and flushing of tanks, lines, and pump.	When this is necessary, make sure all solvents are completely drained.
(c)	Flushing of solvents into receiving storage tank or equipment tanks.	Do not allow even small amounts to flush into storage tank as entire contents may be contaminated thereby.

(2) **Mix Plant Storage Tank and Equipment.** Many investigations and test results point to mix plant storage tanks and associated equipment as the source of contamination.

	POSSIBLE CAUSES	PRECAUTIONS
(a)	Previous material left over in tank when changing to another material.	Any material allowed to remain must be compatible with new material; and the amount remaining in the tank must be insufficient to cause new material to become out-of-specification. If in doubt, check with your supplier. To be on the safe side, tank should be drained or cleaned prior to using tank for each different type or grade of asphalt. Be sure discharge line connects at low point of storage tank to assure complete emptying when changing type or grades of asphalt or cleaning tank.
(b)	Solvents used to flush hauling vehicle tank discharged into storage tank.	Observe unloading operations, caution driver about flushing cleaning materials into storage tank. If possible, provide place for hauler to discharge cleaning materials.
(c)	Flushing of lines and pump between storage tank and hot-plant with solvents and then allowing this material to return to tank.	If necessary to flush lines and pump, suggest providing by-pass valves and lines to prevent solvents from returning to tank. A better solution is to provide insulated, heated lines and pump, thereby eliminating the necessity of flushing.

(d) Cleaning of distributor tank, pump, spray bar, and nozzles with solvents.	Be sure all possible cleaning material is drained off or removed prior to loading. Do not take sample from nozzle until sufficient material has been discharged to insure against taking a contaminated sample.
(e) Dilutions from hot oil heating systems	Check reservoir on hot oil heating system. If oil level is low, or oil has been added, check system for leakage into the asphalt supply.

(3) **Non-Representative or Contaminated Sample.** Test results are greatly dependent upon proper sampling techniques. Extra care, on the part of the sampler, to obtain samples which are truly representative of the material being sampled will do much to eliminate the possibility of erroneous test results by reason of improper sampling. Make sure samples are taken only by those authorized persons who are trained in sampling procedures.

POSSIBLE CAUSES	PRECAUTIONS
(a) Contaminated sampling device (commonly called a "sample thief").	If sampling device is cleaned with diesel oil or solvent, make sure that it is thoroughly drained and then rinsed out several times with material being sampled prior to taking sample.
(b) Samples taken with sampling device from top of tank where, under certain conditions, contaminants can collect on the surface.	In taking a sample from the top of a tank (as required by AASHO Designation T 40) lower sampling device below the extreme top before opening. Note: This sample may come from the top one-third of the tank.
(c) Contaminated sample container.	Use only new clean containers. Never wash or rinse a sample container with solvent.

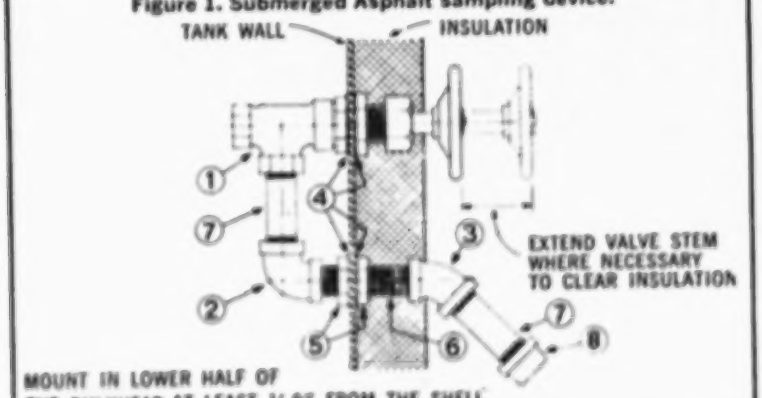
(d) Sample contaminated after taking.	*DO NOT* submerge container in solvent or even wipe outside of container with solvent-saturated rag. If necessary to clean spilled material from outside of container, use a clean dry rag. Make sure container lid is tightly sealed prior to storage or shipment. Ship to testing laboratory promptly.
(e) Samples taken from spigot in lines between storage tank and hot-plant.	If sampling spigot is in suction line between tank and pump, this necessitates stopping pump prior to taking sample. Samples thus taken are by gravity and only representative of material localized in the pipe area of the spigot. Rather, the spigot should be in lines between pump and return line discharge, thereby allowing slow withdrawal of material during circulation. *DO NOT* take sample while hauling vehicle is pumping into storage tank. *DO NOT* take sample without allowing sufficient time for circulation and thorough mixing of material. *DO* drain off sufficient material through spigot prior to taking sample to insure removal of any contaminant lodged in spigot. *DO* take sample slowly during circulation to be more representative of material being used.
(f) Samples taken from unloading line of hauling vehicle.	Drain off sufficient material through spigot prior to taking sample to insure removal of any contaminant lodged there. Sample should be taken after one-third and not more than two-thirds of the load has been removed. Take sample slowly to be sure it is representative of the material being used.

D.03 SAMPLING ASPHALTIC MATERIALS FROM TRUCK TANKS

The following sampling method is based on the use of the submerged sampling valve shown in Figure 1. This sampling valve was selected because, of all the different sampling devices in use, it most nearly fulfills the following criteria:

- Virtually foolproof
- Safe
- Self-draining for cleanliness
- Simple and easy to use
- Provides representative samples
- Inexpensive and trouble-free for installation and maintenance
- Accessible
- Not subject to freezing
- Useful both at time of loading and at destination
- Proved with field experience
- Applicable to all truck tanks

Figure 1. Submerged Asphalt sampling device.



REF. No.	DESCRIPTION	No. REQ.
1	¾" 'VOGT' P-9844 STEEL ANGLE VALVE OR SIMILAR, PANEL MOUNTED	1
2	¾" STEEL OR MALL. IRON 90° ELBOW	1
3	¾" STEEL OR MALL. IRON 45° ELBOW	1
4	ASBESTOS GASKETS SNUG ON THREAD OR WOUND WITH YARN	4
5	¾" 150# SCREWED M. I. LOCKNUT	2
6	¾" x 3½" ± PARALLEL THREADED STEEL PIPE NIPPLE (CUT FROM ¾" STD. TANK NIPPLE IF OTHERWISE UNOBTAINABLE)	1
7	¾" x 3" THREADED STEEL PIPE NIPPLE	2
8	¾" MALL. IRON PIPE CAP	1

A

Method of Sampling Asphaltic Materials from Truck Tanks

1. SCOPE

1.1 This method applies to the sampling of fluid asphaltic materials from transport truck tanks used to convey material from the shipping point.

1.2 The purpose of this method is to obtain samples that will show the true nature and condition of the material. The method outlines a procedure for the taking of samples that represent as nearly as possible the material in the tank.

2. SUMMARY OF METHOD

2.1 The method makes use of a sampling valve installed in an end bulkhead of the truck tank. By proper use of the valve representative samples of the required size can be obtained easily and quickly.

3. SAMPLING VALVE

3.1 This method of sampling is based on the use of the submerged sampling valve shown in Figure 1. This sampling device is constructed entirely of standard pipe fittings. The recommended location is the rear bulkhead of the tank. Any significant contamination from previous loads will be included in the sample taken at this location.

4. SAMPLE CONTAINERS

4.1 Containers for asphalt cement samples shall be one-quart triple-seal friction-top cans.

4.2 Containers for liquid asphalt samples except emulsified asphalt samples shall be one-quart wide-mouth cans with lined screw caps.

4.3 Containers for anionic emulsified asphalt samples shall be one-gallon wide-mouth jars or bottles made of glass or plastic.

4.4 Containers for cationic emulsified asphalt samples shall be one-gallon wide-mouth jars or bottles made of plastic or wide-mouth cans with lined screw caps.

5. SIZE OF SAMPLES

5.1 The size of samples shall correspond to the required sample containers.

6. SAMPLING PRECAUTIONS

6.1 At least one quart of material shall be drained off through the sampling valve before the sample is taken to remove all prior material. The drained off material shall be discarded.

6.2 Sample containers shall be new. They shall not be washed or rinsed. If they contain an excess of solder flux or have an organic lining or if they are not clean and dry they shall be discarded. Top and container shall fit together tightly.

6.3 Care shall be taken to prevent the samples from becoming contaminated. This includes different types of asphaltic materials, solvents, or cleaning fluids.

6.4 After sampling, the sample shall not be transferred into another container.

6.5 The filled sample container shall be tightly and positively sealed immediately after the sample is taken.

6.6 The sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. Any spilled material on the outside of the container shall be wiped with a clean, dry cloth immediately after the container is sealed.

7. SAFETY PRECAUTIONS

7.1 Safety precautions are mandatory at all times when handling asphaltic materials. These safety precautions include, but are not limited to, the ones that follow.

7.2 Gloves shall be worn and sleeves shall be rolled down and *fastened over the gloves at the wrist while* sampling and while sealing containers.

7.3 Face shields should be worn while sampling.

7.4 There shall be no smoking while sampling asphalts.

7.5 The container shall not be held in the hand during sampling and sealing. Tongs or some other device shall be used to hold the container while the sample is being taken.

7.6 The sampler shall stand above and away from the sampling valve as far as practical and on the windward side.

7.7 The sample shall be taken slowly to prevent splashing of the hot material.

7.8 The container shall be placed on a firm level surface to prevent splashing, dropping, or spilling the material during sealing.

8. SAMPLES

8.1 Two samples of the asphaltic material shall be taken. The sampling shall be done after loading of the truck tank is complete and before unloading begins.

9. PROTECTION AND PRESERVATION OF SAMPLES

9.1 Immediately after filling, sealing and cleaning (as required in paragraph 6.6), the sample containers shall be properly marked for identification with a wick marking pencil on the container itself, not on the lid. Linen tags also may be used for identification if they can be securely fastened to the containers in such a manner as to insure that they will not be lost in transit. Linen tags shall not be attached to containers by using the lids to secure them.

9.2 Samples of emulsions shall be packaged, labeled, and shipped in such a manner as to protect them from freezing.

9.3 All samples should be packaged and shipped to the laboratory the same day they are taken. The containers, tightly sealed should be packed in absorbent material, such as sawdust, excelsior, or vermiculite, to reduce the probability of damage during shipment.

9.4 Each sample shall be identified with at least the following information:

9.4.1 Shipper's name and bill of lading or loading slip number.

9.4.2 Date and time of day sampled.

9.4.3 Sampler's name.

9.4.4 Product grade.

NOTE

Three additional methods of sampling asphaltic materials — from stationary tanks, from railroad tank cars at origin, and from railroad tank cars at destination — are available upon request from the nearest office of The Asphalt Institute.

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